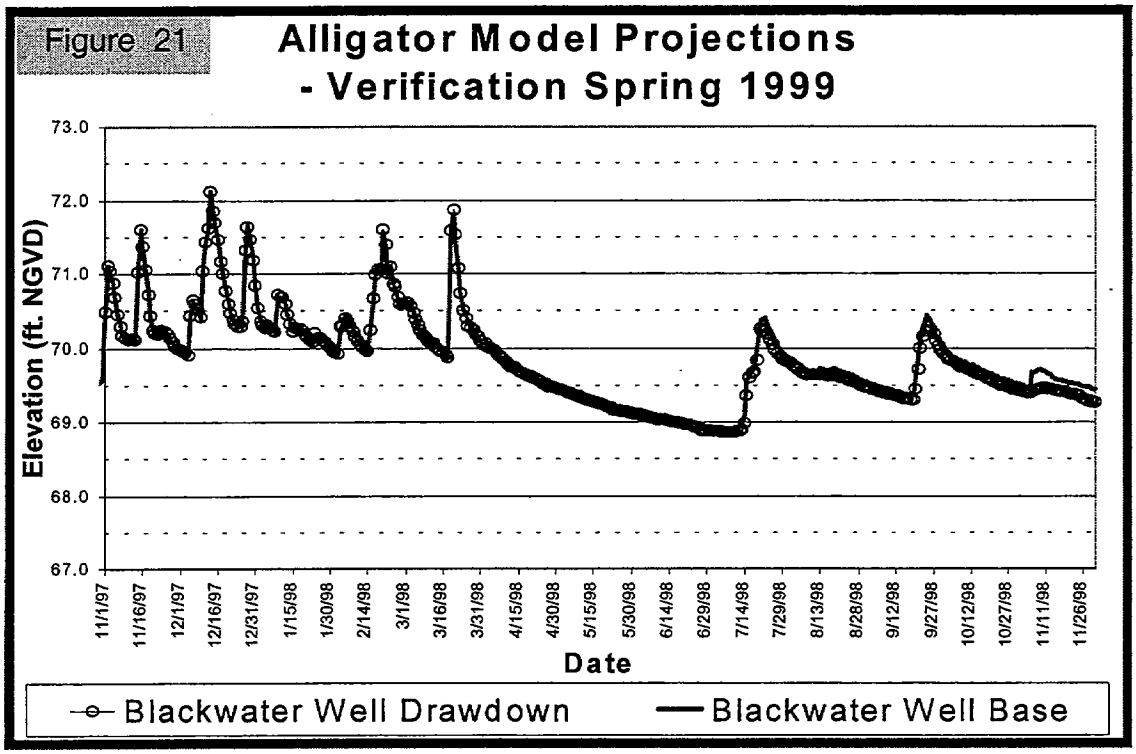
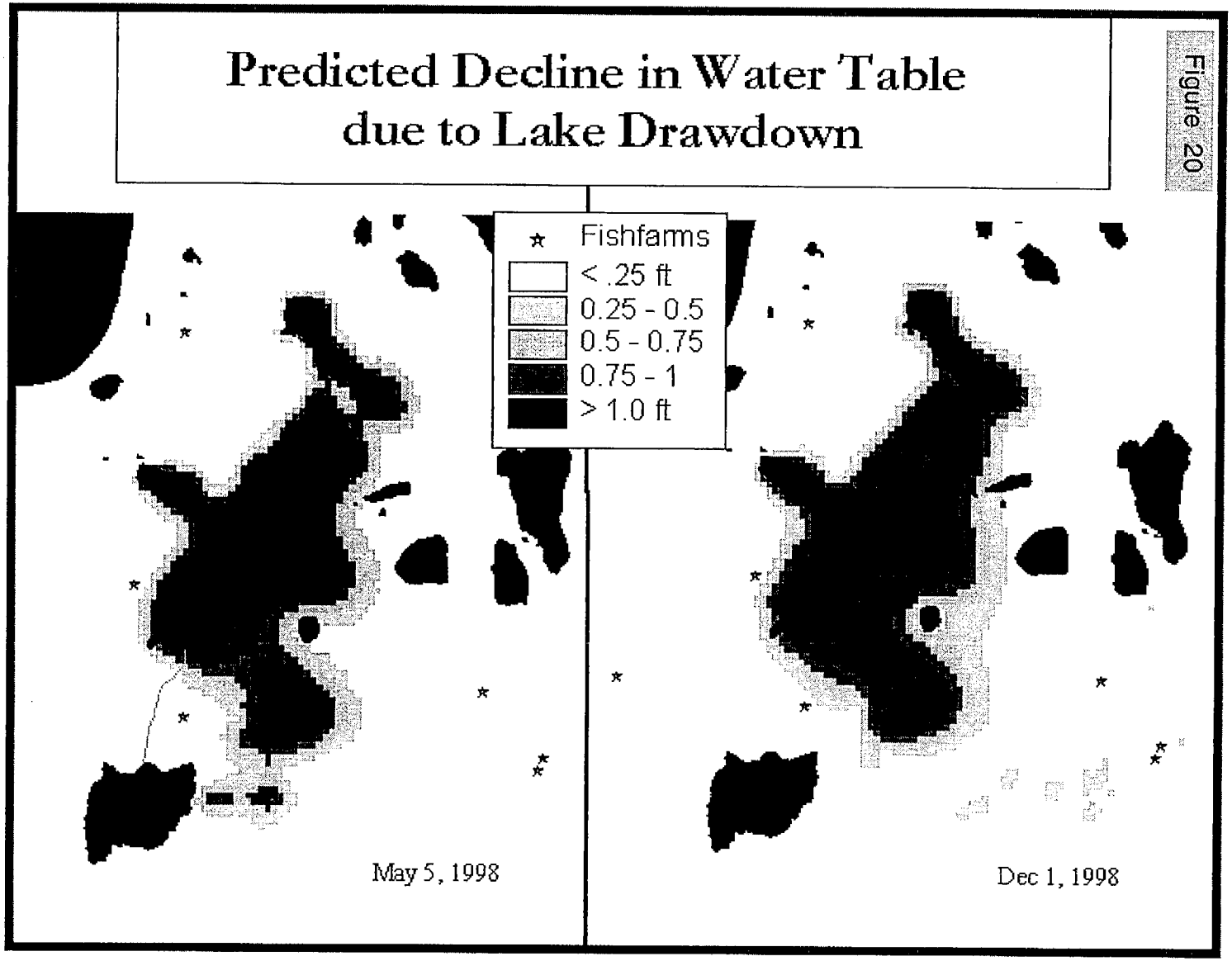
Verification Scenario Results

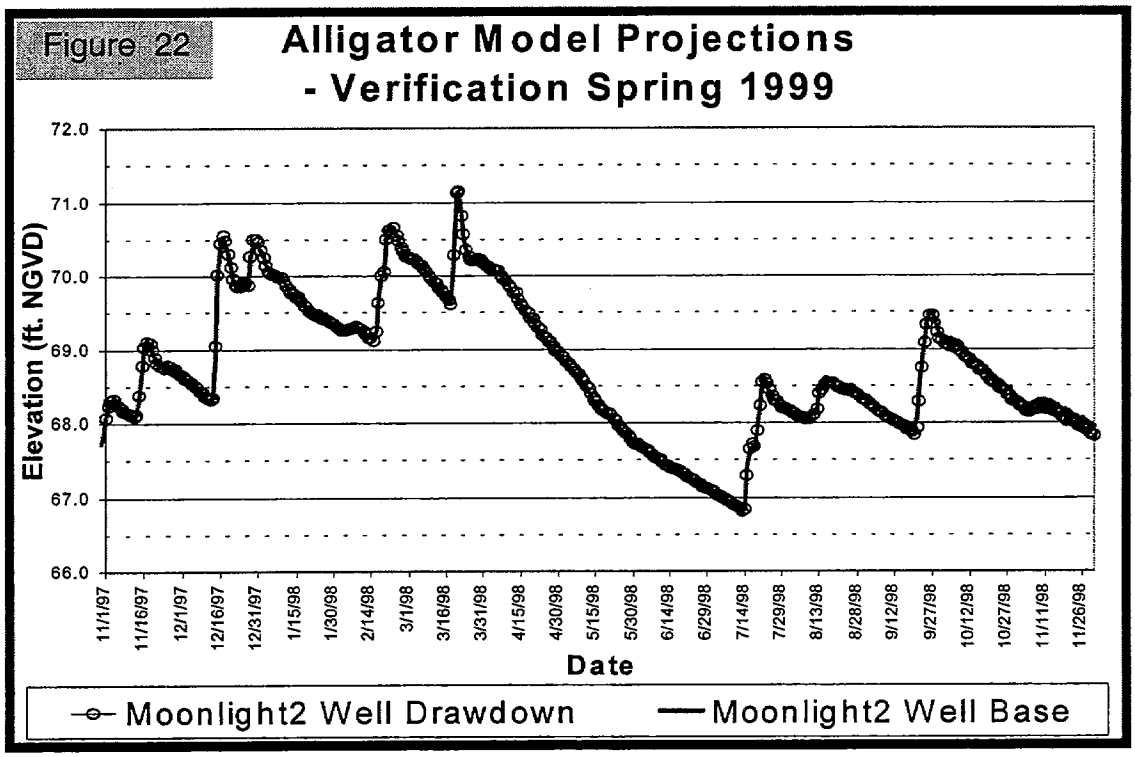
An additional modeling scenario was run using the revised model and 1997-98 weather conditions. The model scenario had the drawdown in Alligator Lake Chain as occurring in spring 1998 to an elevation of 60 feet. Lake stages in Lake Gentry were simulated using the "Hold Gentry" alternative. The projected changes of the model scenario drawdown to the water table is shown on Figure 20 on page 28. The map illustrates that the projected change is less than 0.25 foot at any of the fish farms. Minor changes are projected at Blackwater (Figure 21 on page 27) and Moonlight (Figure 22



on page 29). Appendix N presents the model results in more detail, including hydrographs of projected well stages for base conditions compared with drawdown conditions. The analysis indicates there would be no changes in the aquifer levels at the other fish farms due to the drawdown.

An additional analysis was conducted to estimate the effect of placing a structure in the Blackwater Ditch. This had been identified as a potential way to address the potential impacts to the aquifer at Blackwater Farms during the Spring 1998 Analysis. The modeling scenario was based on 1997-98 weather conditions with a weir controlling water levels 1.5 foot higher than the culvert structure now in place in the Blackwater Ditch. The


Predicted Decline in Water Table due to Lake Drawdown
Figure 20
Fishfarms
< .25 ft
0.25 - 0.5
0.5 - 0.75
0.75 - 1
> 1.0 ft
May 5, 1998
Dec 1, 1998



modeling shows that the changes to the aquifer at the Blackwater Farm due to the drawdown would have been offset with the weir in place (Figure 23 on page 30).

Conclusions

Concerns were raised by the aquaculture community regarding possible impacts to their operations by the proposed drawdown. The concern is that declines in lake levels could influence the ground water levels in the immediate area, and adversely impact their operations. The concerns of the aquaculture community were investigated and a preliminary analysis of the potential impact was prepared in September 1997. Further investigation involved frequent meetings, site visits, analysis of existing surface and groundwater data, installation of groundwater monitoring wells at the fish farms and other locations, and groundwater modeling.

The preliminary analysis concluded that fish farm ponds in the project area are at risk of not being able to maintain adequate water levels in them under natural conditions. This condition exists without any artificial drawdown of Alligator Lake. It also concluded that the proposed drawdown may change aquifer levels at Blackwater Fishery and Moonlight Fisheries. The

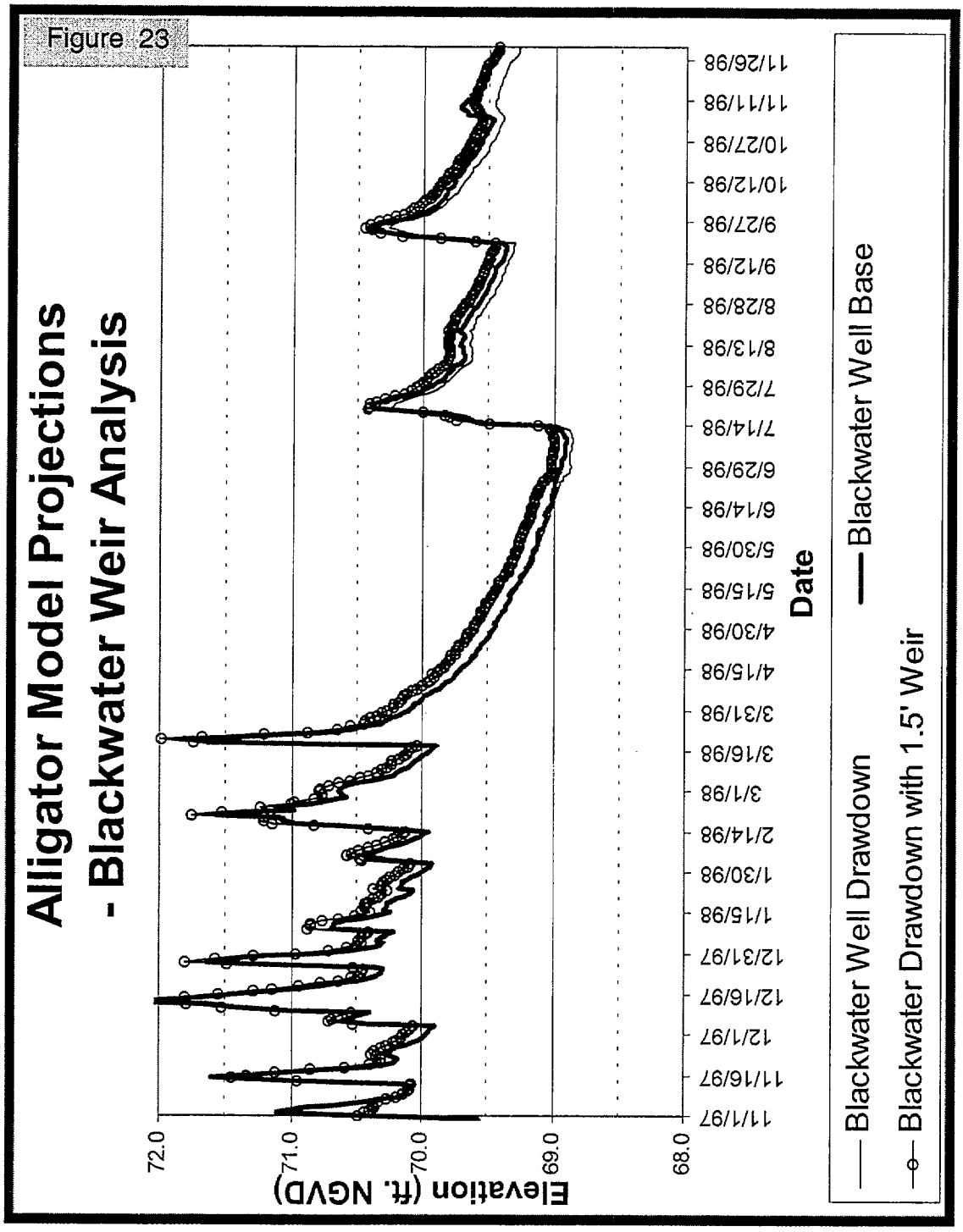


Figure 23
Alligator Model Projections
- Blackwater Weir Analysis
Elevation (ft. NGVD)
72.0
71.0
70.0
69.0
68.0
Date
11/1/97
11/16/97
12/1/97
12/16/97
12/31/97
1/15/98
1/30/98
2/14/98
3/1/98
3/16/98
3/31/98
4/15/98
4/30/98
5/15/98
5/30/98
6/14/98
6/29/98
7/14/98
7/29/98
8/13/98
8/28/98
9/12/98
9/27/98
10/12/98
10/27/98
11/11/98
11/26/98
Blackwater Well Drawdown
Blackwater Well Base
Blackwater Drawdown with 1.5' Weir

preliminary analysis concluded that the proposed lake drawdown would not change the aquifer levels at the other fish farms such as Castelli Farms, Sunset Tropicals, Mako Tropicals, Exotic Fish, and Exotic Acres.

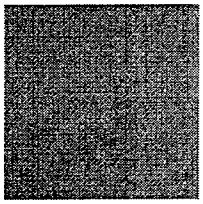
The subsequent investigation in spring 1998 and computer modeling projections support the conclusions from the preliminary analysis. Changes to the water table are projected under certain conditions at Blackwater Fishery and Moonlight Fisheries.

Under the Typical Condition Scenario, the change to the aquifer level at Blackwater Fishery is projected to be less than 0.4 feet. The change to the aquifer level at Moonlight Fisheries under typical conditions is projected to be less than 0.3 feet.

Under the Severe Drought Condition Scenario, the change to the aquifer level at Blackwater Fishery is projected to average 0.1 feet during the first year of the drought and 0.4 feet during the second year. Maximum change is projected to be 0.7 feet. The analysis indicates that the drainage canal at Blackwater Fishery has a major influence on water levels in the fish ponds. The ponds can be expected to be dry or almost dry due to the canal's influence during drought conditions. The change to the aquifer level at Moonlight Fisheries is projected to average 0.4 feet during the first year and 1.1 feet during the second year. Maximum change is projected to be 1.0 feet during the first year and 1.5 feet during the second year. The aquifer level changes at Moonlight Fisheries can be substantially reduced if Lake Gentry is not drawn down to its original target elevation. The changes to water levels in the fish ponds at Moonlight Fisheries are expected to be less than those in the aquifer.

The modeling indicates that the proposed lake drawdown will not have a measurable change to the water table aquifer levels at Castelli Farms, Sunset Tropicals, Mako Tropicals, Exotic Fish, and Exotic Acres fish farms.

The verification analysis of spring 1999 confirmed the conclusions from the previous analysis. The placement of a weir in the Blackwater Ditch can offset the potential aquifer level changes due to the drawdown at Blackwater Farm. The alternative of postponing the drawdown of Lake Gentry can offset the potential changes to the aquifer levels due to the drawdown at Moonlight Farms except under extreme drought conditions.



Appendices

Appendices

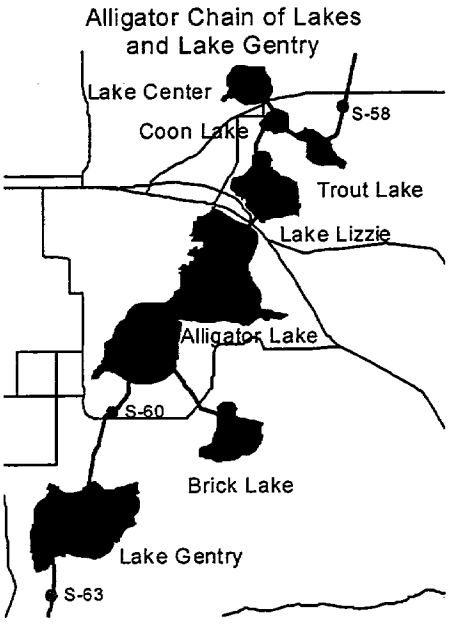
Appendix A. Overview of Habitat Enhancement Project

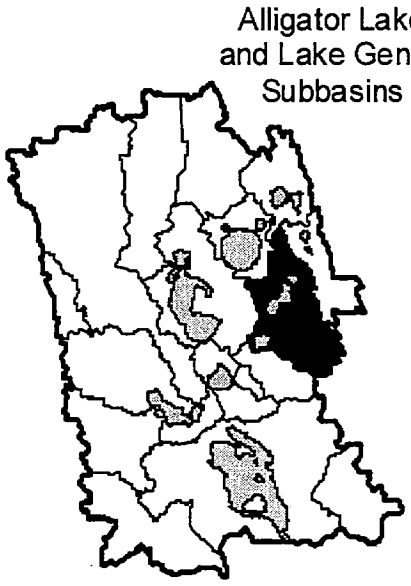
Overview of Habitat Enhancement Project

Introduction

The Alligator Chain of Lakes is a subset of the Kissimmee Chain of Lakes. The Alligator Chain, located in Osceola County, consists of lakes: Alligator, Brick, Lizzie, Center, Coon, and Trout. These lakes are connected by a series of canals allowing water flow and navigation between the lakes. The South Florida Water Management District operates control structures S-58 to the north and S-60 to the south to regulate water levels on these lakes. Water from these lakes is discharged south to Lake Gentry, although limited flow can be sent north towards Lake Joel. Lake Gentry water levels are controlled by Structure S-63 and is operated by the District. Flow is discharged south to Cypress Lake.

Florida's historic cyclic rainfall pattern produced a wide range of water level fluctuations in the Alligator Chain. Water level fluctuations during certain years exceeded five feet. Aquatic plant, fish, and wildlife populations evolved under this cyclic hydrological pattern, with periodic extreme water fluctuations playing an important role in maintaining healthy ecosystems. In the early 1960s major channelization occurred in the Kissimmee Basin, and





water control structures were placed at many lake outlets. Since the completion of the flood control project, water levels have been artificially restricted within a very narrow range of fluctuation; historic high water levels have been artificially eliminated. Generally fluctuations on the Alligator Chain are now constrained within a two foot range

As a result of long-term stabilized water levels, organic sediments have built up on lake bottoms. Desirable biological productivity decreases as these sediment depths increase. Native aquatic vegetation begins to decline, and is no longer capable of maintaining diverse wildlife communities. As a consequence, the diversity and abundance of fish food organisms that depend on these plants are decreased. In turn, this directly contributes to reduced sportfish production and decreased fishing success. Dense growths of aquatic plants quickly consolidate bottom sediments deposited near low pool stage, forming organic berms around the lakes. Formation of tussocks also occurs as a result of the built up organic material and changes in aquatic plant communities.

Problems associated with degraded habitat can be reversed, to a large extent, through the use of an extreme lake drawdown. This technique was experimentally applied in Lake Tohopekaliga during 1971. Based on the success of this effort, the Florida Game and Fresh Water Fish Commission has implemented extreme drawdown programs on several other lakes. This restoration technique involves dewatering lakes to historic lows to allow consolidation of bottom sediments. Extreme drawdowns mimic low water conditions prior to flood control (i.e., droughts), which historically occurred about every seven years in the Kissimmee Chain. Recently, more intense in-lake restoration activities have been required to aggressively address long term fish and wildlife habitat deterioration. Muck removal, burning, and herbicide applications have been successfully used to reduce dense vegetation, tussock formation and organic build-up on lake bottoms.

Habitat Management Proposal

The Commission, in cooperation with the District, is planning a major habitat enhancement project for the Alligator Lake Chain and Lake Gentry. The Commission is recommending implementation of a program that will include an extreme drawdown, muck removal, burning, and aquatic plant management. These activities are necessary because of the heavy build-up of organic material, tussock formation, and the dense growth of aquatic vegetation around the shoreline of all six lakes.

Based on previously gained knowledge and experience, a drawdown and muck removal project on the Alligator Lake Chain should provide the following benefits:

- Elimination of tussock problems
- Improvement of bottom substrate, especially in highly degraded areas
- Increased diversity of desirable vegetation communities and re-establishment of vegetation in barren areas
- Increased production of invertebrate and vertebrate fish food organisms
- Additional revenue for the local economy generated by a significant increase of fisherman effort and success for sportfish species.
- Increased monetary value of the fishery resource through increased production

Water Level Analysis

The Alligator Chain of Lakes and Lake Gentry water level schedules will be modified for the drawdown. For the Alligator Chain, the schedule would be changed to allow a lowering to the planned drawdown elevation of 60.0' by March 1. This level will be maintained until June 1, when refilling can begin. For Lake Gentry, the stage will be lowered to the planned drawdown elevation (56.5') by March 1. It would be maintained until June 1, when refilling can begin.

In order to lower lake levels to the desired elevations in a timely fashion, it will be necessary to use pumps. A pump is needed to pump water to the north. It will be placed in the canal north of Trout Lake (Canal C-32C). The canal will be blocked off from the lake by an earthen plug with a culvert riser to prevent water from flowing back into the lake. This plug will block navigation between Trout Lake and the District's Structure S-58 in Canal C-32C. The plug will be removed after reflooding when the water level in Trout Lake is equal with Lake Joel. Lake Gentry can reach drawdown elevation (56.5' msl) by the target date with gravity discharge.

In-lake Restoration Work

Approximately 4,200 acres in the Alligator Chain of Lakes and Lake Gentry will be exposed. Organic bottom sediments should compact and consolidate during the scheduled ninety day drying period. Coverage of beneficial aquatic vegetation such as Kissimmee grass, eelgrass and bulrush should

increase following refill, due to germination of seeds exposed during the extreme drawdown. In-lake activities such as muck removal, burning of dense vegetation and a lakewide cleanup will be implemented to enhance aquatic habitat. Muck removal is planned for seventeen sites, totaling almost fifteen miles of shoreline, and will be conducted in all lakes. Approximately 475,000 cubic yards of organic material will be removed. The material will be disposed of on upland sites or in wildlife islands

Summary

The Alligator Lake Chain and Lake Gentry Habitat Enhancement Project is an important effort to improve desirable aquatic habitat, fish, and wildlife resources in a portion of the Kissimmee Chain of Lakes. The Commission is the lead agency in this effort and is coordinating with several other agencies to make the project a success. Over 475,000 cubic yards of organic material will be removed from six lakes along almost fifteen miles of shoreline. Increases in the density and diversity of desirable vegetation communities and re-establishment of vegetation in barren areas will occur. Increases in production of invertebrate and vertebrate fish food organisms will occur which will lead to increases in fisheries. Significant increase in fish per hour of fishing effort for the harvest of sportfish species should occur, which will in turn generate additional revenue for the local economy.

Appendix B. Preliminary Hydrologic Analysis - September 1997

Preliminary Hydrologic Analysis - September 1997

A preliminary analysis of the potential impacts of the proposed project was prepared in September 1997[1]. This appendix contains the preliminary analysis.

1. The preliminary analysis was based on limited data and the conclusions of this analysis were tentative. Subsequent analysis and modeling was done to address uncertainties identified. The preliminary analysis is presented to provide perspective to the need and basis for the subsequent detailed analysis. The reader is cautioned to the tentative nature of the conclusions in this appendix.

Alligator Lake Fish Farm Issue: Concerns on possible negative impacts to fish farm located near the Alligator Chain of Lakes caused by the proposed extreme lake level drawdown.

BACK GROUND INFORMATION

Figure 1 illustrates the ground water tables under simplified uniform, homogeneous, and isotropic soil conditions after an extended period of a lowered lake level(dropped from level 1 to level 2). The water table responds differently to different soil types such as clay and silt which have low permeability and Miami Oolite which has very high permeability. The location and depth of the fish pond is also an important factor to be considered.

The project area is located near the Alligator Chain of Lakes in Osceola County, Florida. There are two major ground water systems(surficial and Floridan) and one Intermediate Confining Unit(ICU) in the area. The Surficial Aquifer System(SAS) consists of the water table aquifer, which ranges in thicknesses from 20 feet up to 270 feet. The Floridan Aquifer System(FAS) ranges in thicknesses of 100 feet to 2,100 feet. The ICU consists mainly silts and clays of the Hawthorn Group, having thicknesses ranging from 1 foot to 370 feet. Therefore, the ground water system in the project area is much more complicated than shown in Figure 1. The SAS is of primary concern in this issue.

In general, the water table declines due to seepage into lakes, streams, and canals; by evapotranspiration; water use; and downward leaking to the Floridan Aquifer System(FAS). Rainfall is the primarily recharge to the SAS; ground water inflows from outside the project area are minor.

There are six fish farmers who have expressed concern about potential impacts by the proposed extreme lake level drawdown. The soil types for these fish farms are listed below:

1. Blackwater Fishery Inc., 3460 Hickory Tree Rd, St. Cloud, Florida, has soil types of Myakka, and Placid series according to Soil Survey Map for Osceola County. This farm is within one mile(3,000 feet) west of Alligator Lake.

2. Moonlight Fishery Inc., 6458 Hickory Tree Rd, St. Cloud, Florida, has Myakka and Placid series. This fish farm is located between Alligator Lake and Lake Gentry.

3. Sunset Tropicals, 3981 Doe Drive, St. Cloud, Florida, has Samsula series. This fish farm is outside Alligator Lake basin and is in Lake Tohopekaliga basin.

4. Castelli Farms, 7580 E. Bronson Memory Highway, St. Cloud, Florida, has Myakka, Immokalee and Placid series. This farm is

located about 3.5 miles east of Alligator Lake.

5. Exotic Fish Inc., 4525 Cypress Creek Ranch Rd, St. Cloud, Florida, has Immokalee and Samsula series. This farm is located about 5.5 miles east of Alligator Lake.

6. Exotic Acres, 4580 Cypress Creek Ranch Road, St. Cloud, Florida, has Samsula and Placid series. This farm is located about 5.5 miles east of Alligator Lake.

According to the Soil Survey(information good for 5 to 6 feet below land surface) of Osceola County, the Myakka, Placid, Immokalee, and Samsula series can be considered as excess fine sand which contains excess silt and clay. This implies that the permeability of those excess fine sands is relatively lower than sandy loam soil. The South Florida Water ManagementDistrict(District) operates the flood control system in the Kissimmee Chain of Lakes and has no problem maintaining desirable water levels in the lake system except during drought periods. In other words, the water table, due to low permeability of the soil in the areas, will be more of an arch shape rather then a straight line as shown in Figure 1. The extent of the drawdown effect(cone of influence line) could be better estimated with field data. The shape of the water table and the potential impact of lake level drawdown on the above mentioned fish ponds depend on other factors such as soil conditions(textures, structures etc), lake operations for flood control, rainfall, water withdraws, and evapotranspiration processes.

WELL DATA ANALYSIS

There are two Surficial Aquifer System(SAS) wells within three and one half miles of Alligator Lake. They are OS181 Well and OSS68 Well. OS181 Well, located on the south side of U.S. Highway 192 just south of the junction of County Road 534, is approximately 1.5 miles from Alligator Lake. This non-artesian well, is 6 inches in diameter 6, has a depth of 16 feet, and is cased to 14 feet, was constructed by USGS in 1948. Daily water levels are available through current. The second well, (OSS68 Well), is located on the south side of U.S. Highway 192 inside Castelli Farms (about 3.5 miles from Alligator Lake). The well is non-artesian well, has a diameter of 6 inches, has 2 inch PVC pipe 105 feet in depth, is gravel packed from 80 to 105 feet, and is cased to 80 feet with concrete. The well was installed in 1992 and has monthly readings for period from 1992 through 1994. From a recent on-site visit(9/11/97) this well is no longer functional.

Figure 2 presents a comparison of water levels from OS181 Well, OSS68 Well, and S60 Headwater(water level indicator for Lake Alligator). The maximum and minimum daily readings from May 1992 through September 1994 at OSS68 Well were 69.08 and 67.16 feet

NGVD, respectively. The water table readings at Castelli Fish Farms(OSS68 Well) consistently ranged between Alligator Lake(S60 Headwater) and at OS181 Well(which is located between Alligator Lake and Castelli property). In addition, the water levels at Brick Lake will be maintained at 62.5 feet NGVD as much as possible during the lake drawdown. Cat lake, about a mile north from Castelli property, will not be artificially drawdown. It is more than likely the drawdown of Alligator Lake will not have direct impact on the fish pond in Castelli Farms. However, it would have been difficult to maintain a water depth of five to six feet in those fish ponds during the drought conditions experienced in 1970s and 1980s due to significant rainfall deficit and lower regional water table levels(more discussion on this follows).

Figure 3 presents the daily maximum, mean, and minimum water table readings during each month for the period from January 1970 through December 1992 at OS181 Well. The water table fluctuates approximately two feet within a month but fluctuates much more from month to month and year to year. For example, the water table fluctuated over five feet during 1974. The water table dropped to 71.2 feet NGVD during 1981. Most of the fish farms in the project area did not exist prior to 1985. The water tables have been relatively higher for period since 1986 as compared to the period from 1970 through 1982. The only fish farm known to have existed and experienced the 1980-81 drought is Blackwater Fishery Inc. At that time the fish ponds in Blackwater Fishery had virtually no water. However, the fish farmer managed to keep enough water in their ponds to save some stock(per Mrs. Walther, owner of Blackwater Fishery Inc.).

Figure 4 presents the historical maximum, mean, and minimum water table readings for each calendar month for OS181 Well. February and March have slightly lower fluctuation, and wet season months have a greater differential in which rainfall variations play an important role. This figure indicates the difference between high and low water table in any month can be more than five feet under natural conditions(based on 25 years data at OS181 Well).

Figure 5 presents the monthly rainfall at stations MRF8(near Lake Myrtle) and MRF14(near Holopaw). Rainfall plays important role on the water table fluctuations(Figure 3).

Figure 6 presents the historical daily maximum, mean, and minimum stage elevation at S60 Headwater for the period from January 1970 through December 1994. The water level at S60 Headwater during 1980-81 drought was below 60 feet NGVD from May 1 through August 26, 1981. The lowest level reached was close to 59.5 feet NGVD(about one foot higher than the proposed drawdown level). The land elevation at Blackwater fish farm is about 70 feet NGVD with pond depths between five to six feet. The water table is estimated to have been at elevation 64 feet NGVD during 1980-81 drought. The rainfall during 1981 was 35.67 inches over the Kissimmee Chain of Lakes, which was about 70 % of its annual normal rainfall. In some months, the monthly rainfall during 1980-81 less tnan 10 % normal.

The influence of lake level declines with distance on the shallow ground water table does not appear to extend beyond the OS181 Well site. This is based on two facts; first, the relative head differences between the water level at OS181 Well and S60 Headwater are consistent through out the available record period even during severe drought of 1980-81, in which the head differences are close to their long term averages except during summer of 1980 when rainfall was far below its normal(Figure 7); second, the water table readings at Castelli Farms are consistently ranged between OS181 Well and S60 Headwater.

Figure 8 presents a water level comparison between OS181 Well, S60 Headwater and Lake Joel Well. Lake Joel well is located on the southwest shore of Lake Joel, and was constructed by U.S.G.S. in 1969. This is an artesian well, 8 inches in diameter, has a depth of 750 feet, and is cased to 394 feet. This is a Floridan Aquifer well. The water level fluctuations of these three sites were very consistent during 1980-81 drought, which indicates that the severe drought of 1980-81 had significant effect on the regional water table decline including Floridan Aquifer system.

Since there are only two shallow well data available for this analysis, it is rather difficult to pin point the exact impact to Blackwater and Moonlight Fish Farms. In addition, there are many parameters that interact with each other. Rainfall especially plays such an important role in ground water table recharge. If rainfall in the regional area repeats its 1980-81 conditions, the water tables in Blackwater Fish Farm could be up to an additional one foot lower than the 1981 conditions if the Alligator Lake level is dropped and held at 58.5 feet NGVD. However, with normal rainfall, the water table will not be lower than 1981 level. Figure 7 presents the effect of rainfall on the head differences between OS181 Well and S60 Headwater. Head difference increases with rainfall(that means a higher water table). Additional on-site data would help to better define the ground water response to local rainfall under various soil types, and the subsequent water table decline in relation to lake level drop.

CONCLUSIONS

The following conclusions can be made based on the available field data in the project area:

1. The wide range of water table fluctuations(5 to 6 feet) at the OS181 Well presented in Figures 3 and 4 indicates the fish farm ponds having 5 to 6 feet depths in the project area are at risk of not being able to maintain adequate water levels in them under natural conditions without any artificial drawdown of Alligator Lake. The proposed extreme drawdown on the Alligator Chain of Lakes may potentially impact the water levels of the fish ponds at Blackwater and Moonlight Fishery

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which are near Alligator Lake. However, the potential negative impact may also caused by rainfall deficit and water use, in addition to how much is caused by artificial drawdown. The monitoring of on-site rainfall and shallow ground water table will provide information for such assessments.

2. The influence on the shallow water table by the drawdown of Alligator Lake will not extend beyong the OS181 Well site. This can be concluded from the Figures 2, 3 and 7 as discussed in the well data analysis section. The available data indicate that the proposed lake drawdown will not have a measurable negative impact to the water levels of those fish farms such as Castelli, Sunset Tropicals, Exotic, and Exotic Acres Fishery because their locations are beyond the cone of influence.

3. The decline of the shallow water table in the project area depends on a number of factors, including seepage into lakes, streams, and canals; evapotranspiration; water usages; and downward leaking to the Floridan Aquifer System(Figure 8). Rainfall is the primarily recharge to the Surficial Aquifer System, and ground water inflows from outside the project area are minor.

4. The available rainfall stations used in this analysis are located near the project area but outside fish farm properties. Additional on-site data such as water table and rainfall data would help better define the ground water table response to local rainfall under different soil types, and the water table decline in relation to lake level drop.

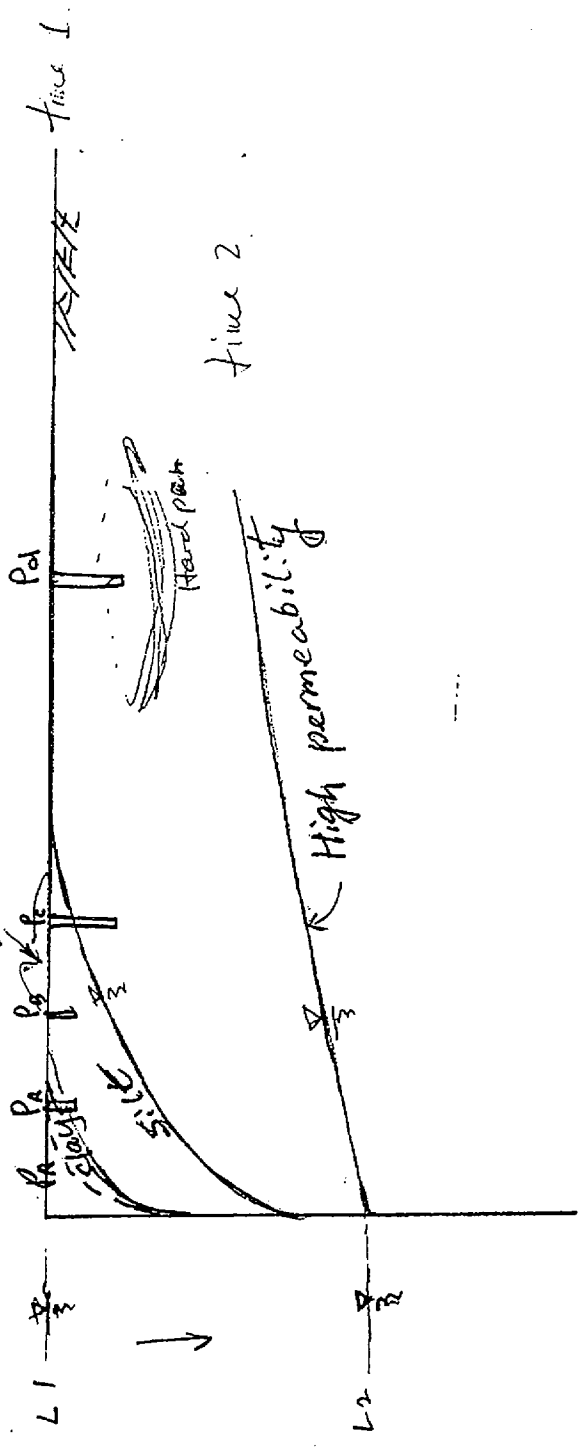

Low permeability
High permeability
Hard pan
time 1
time 2
Slight
Silt
L1
L2

Figure 1

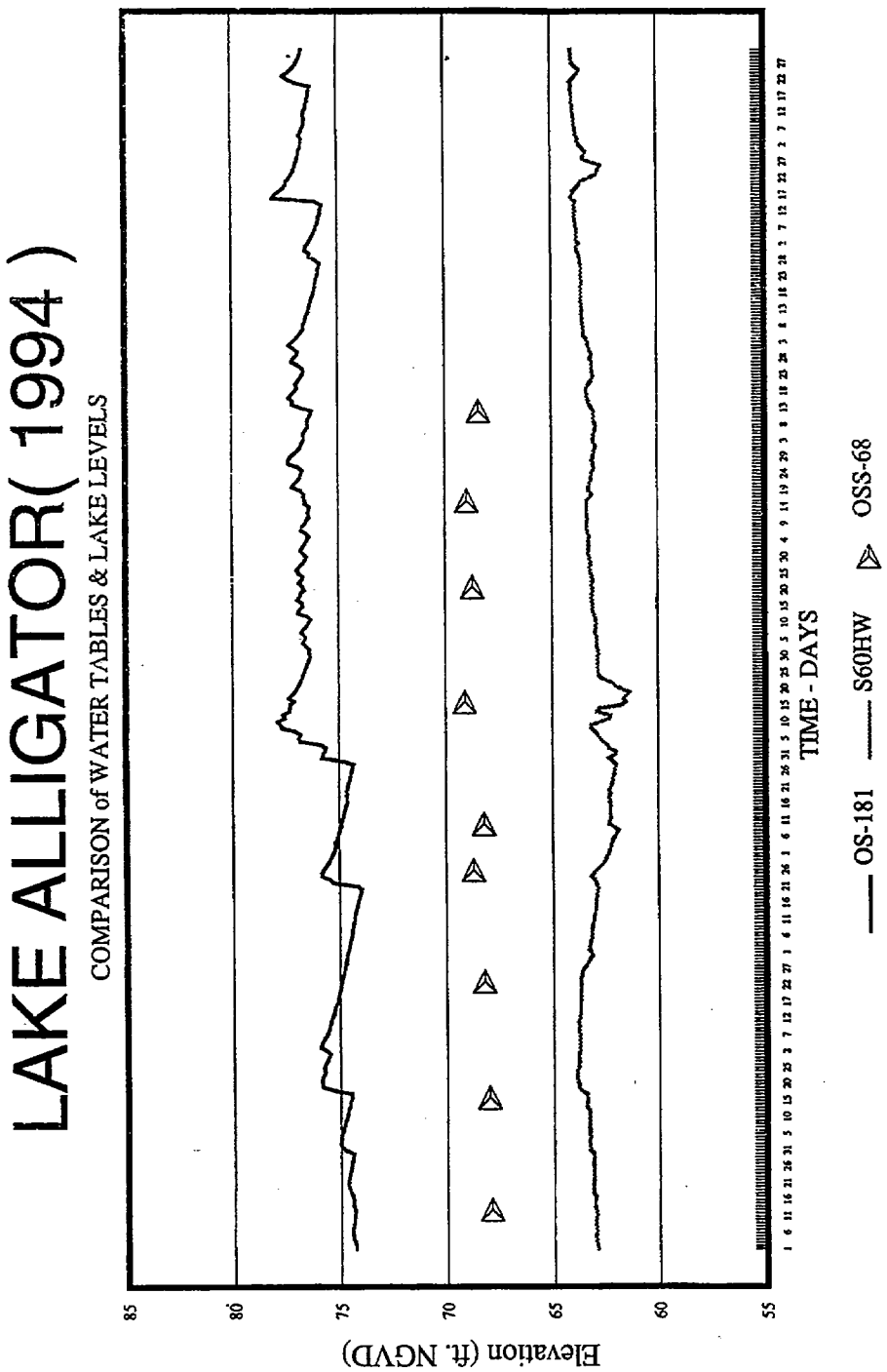

LAKE ALLIGATOR(1994)
COMPARISON of WATER TABLES & LAKE LEVELS
Elevation (ft. NGVD)
85
80
75
70
65
60
55
TIME - DAYS
OS-181
S60HW
OSS-68

Figure 2

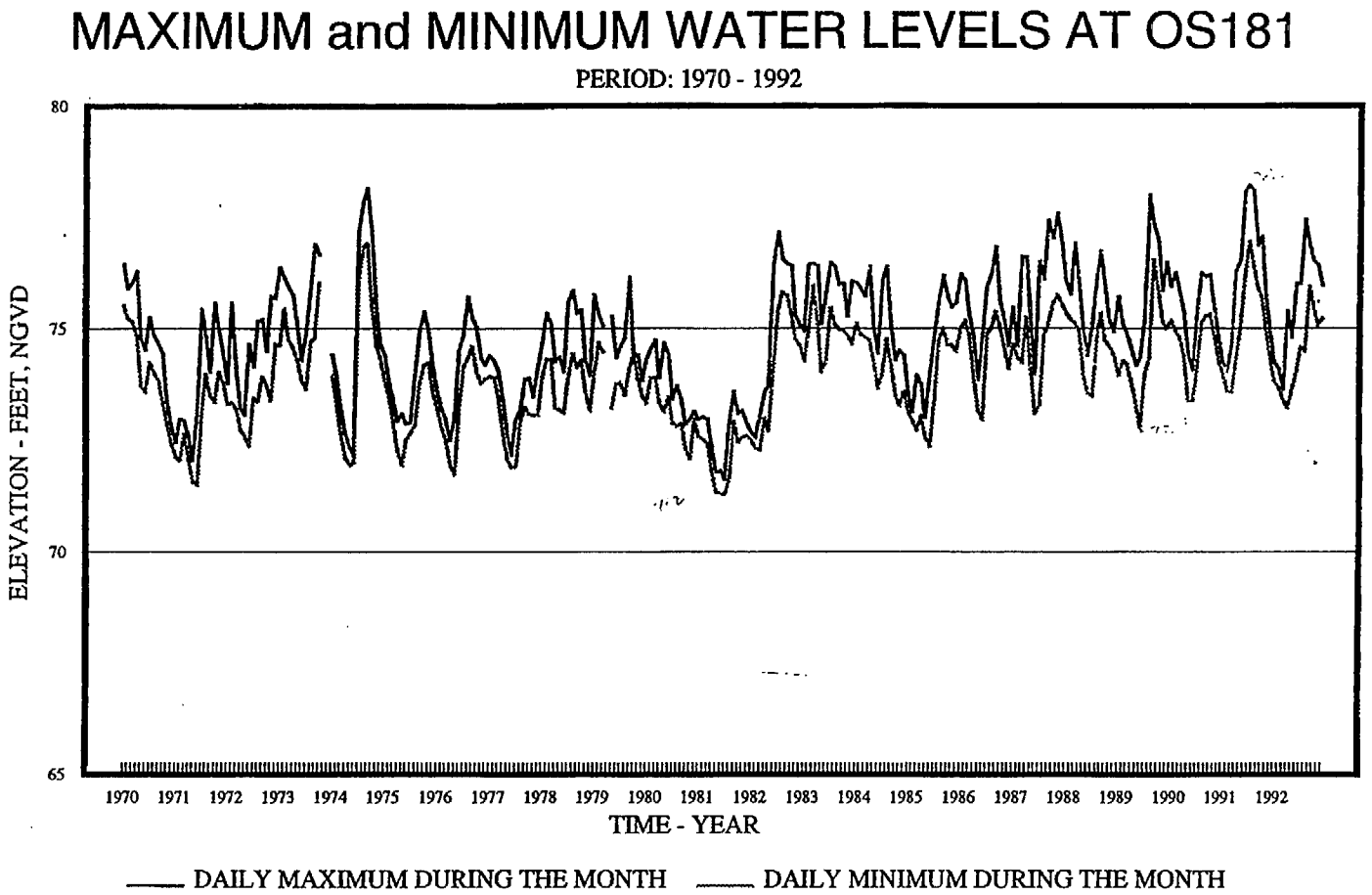
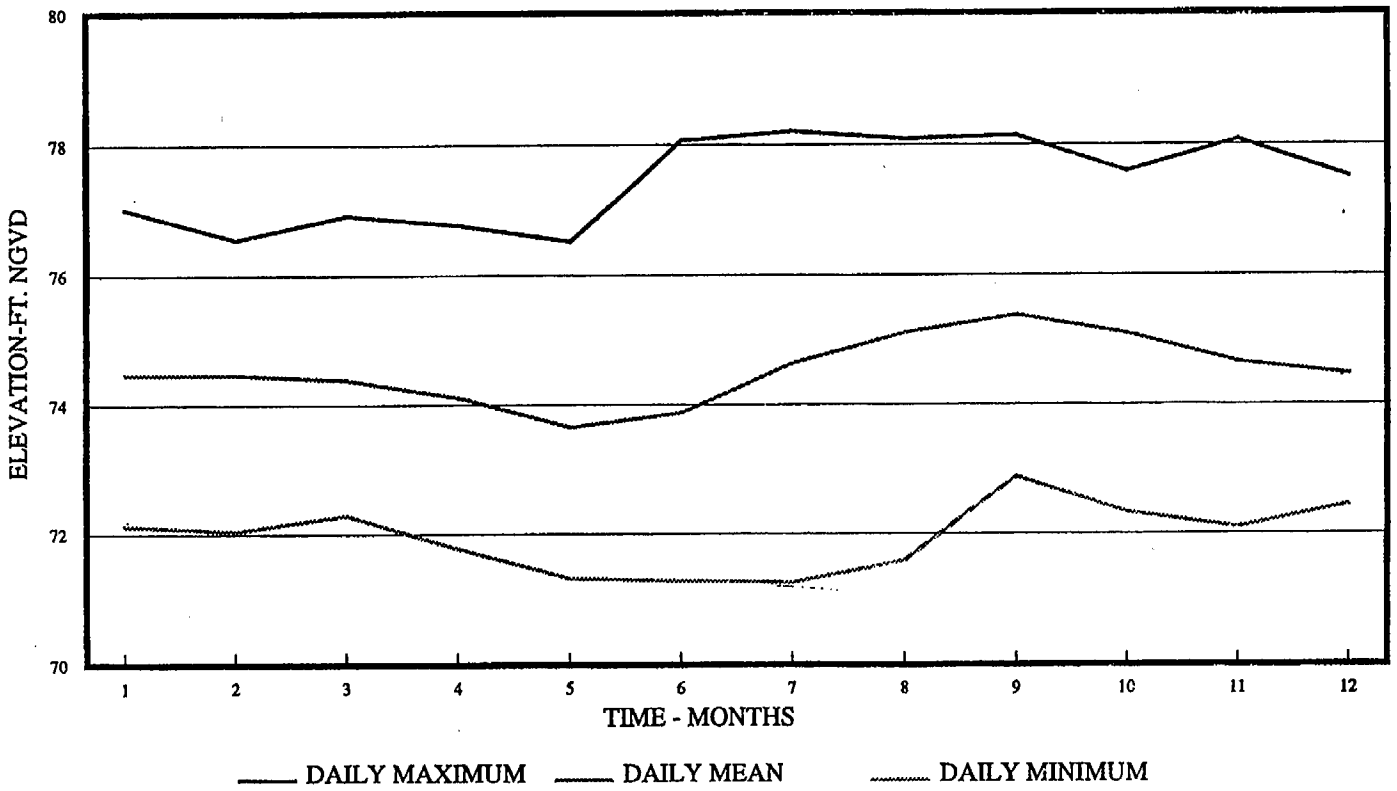

MAXIMUM and MINIMUM WATER LEVELS AT OS181
PERIOD: 1970 - 1992
ELEVATION - FEET, NGVD
80
75
70
65
1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992
TIME - YEAR
DAILY MAXIMUM DURING THE MONTH
DAILY MINIMUM DURING THE MONTH

Figure 3

HISTORICAL MAXIMUM, MEAN, MINIMUM AT OS181 WELL

1/08/1970 - 12/31/1995



DATA SHOWN FOR EACH CALENDAR MONTH

Figure 4

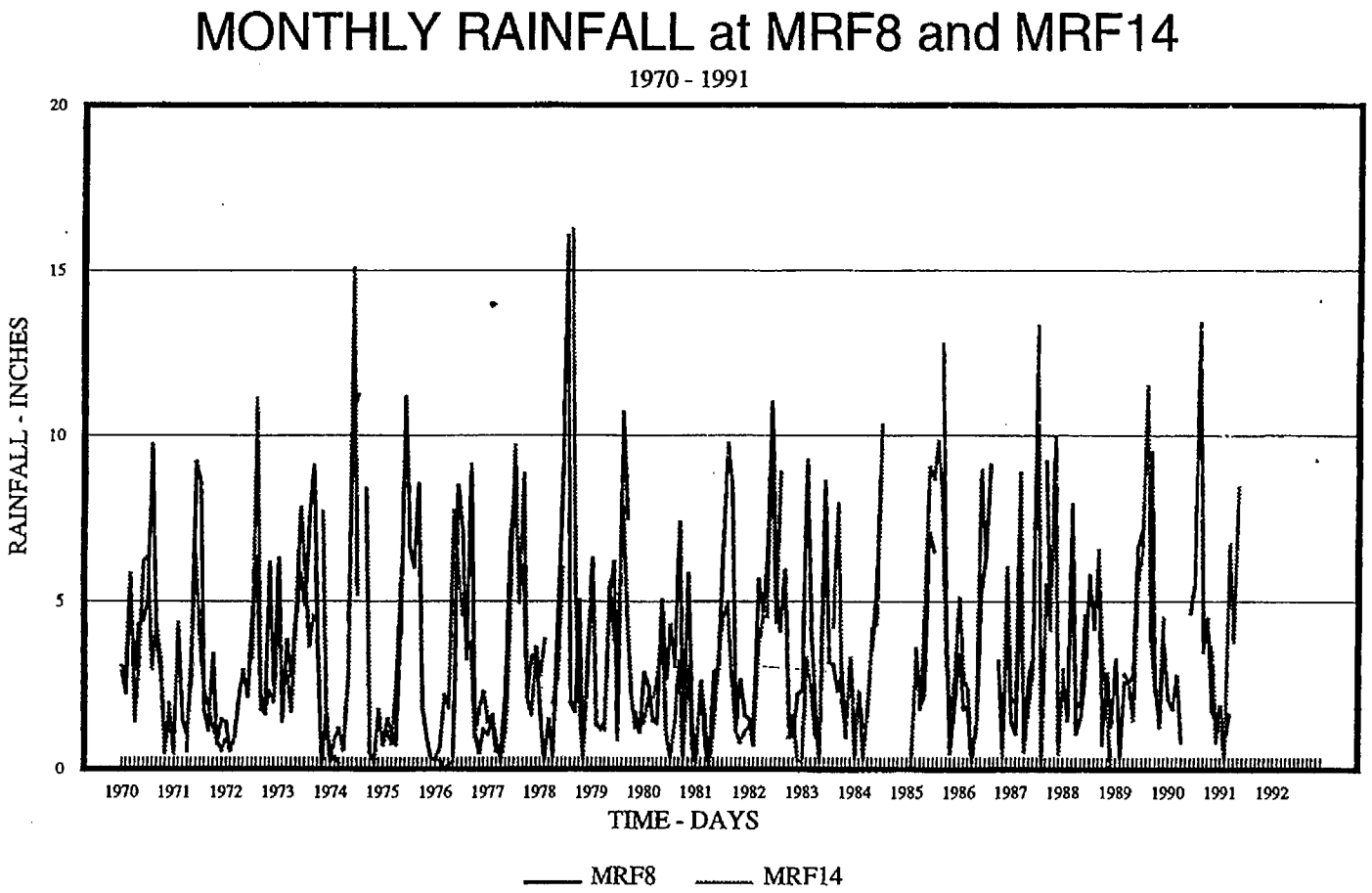

MONTHLY RAINFALL at MRF8 and MRF14
1970 - 1991
RAINFALL - INCHES
0
5
10
15
20
1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992
TIME - DAYS
MRF8
MRF14

Figure 5

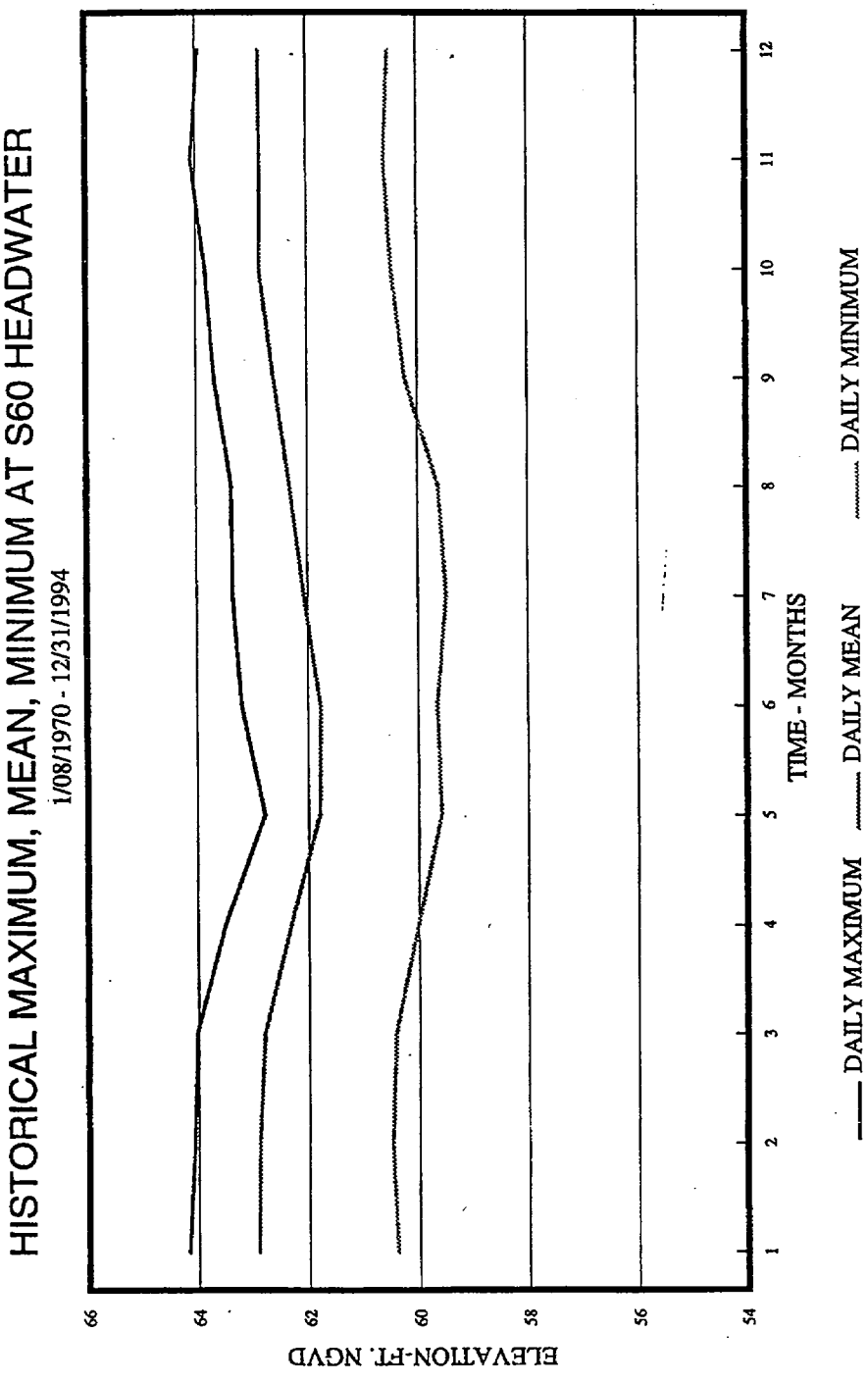

HISTORICAL MAXIMUM, MEAN, MINIMUM AT S60 HEADWATER
1/08/1970 - 12/31/1994
ELEVATION-FT. NGVD
66
64
62
60
58
56
54
1
2
3
4
5
6
7
8
9
10
11
12
TIME - MONTHS
DAILY MAXIMUM
DAILY MEAN
DAILY MINIMUM
DATA SHOWN FOR EACH CALENDAR MONTH

Figure 6

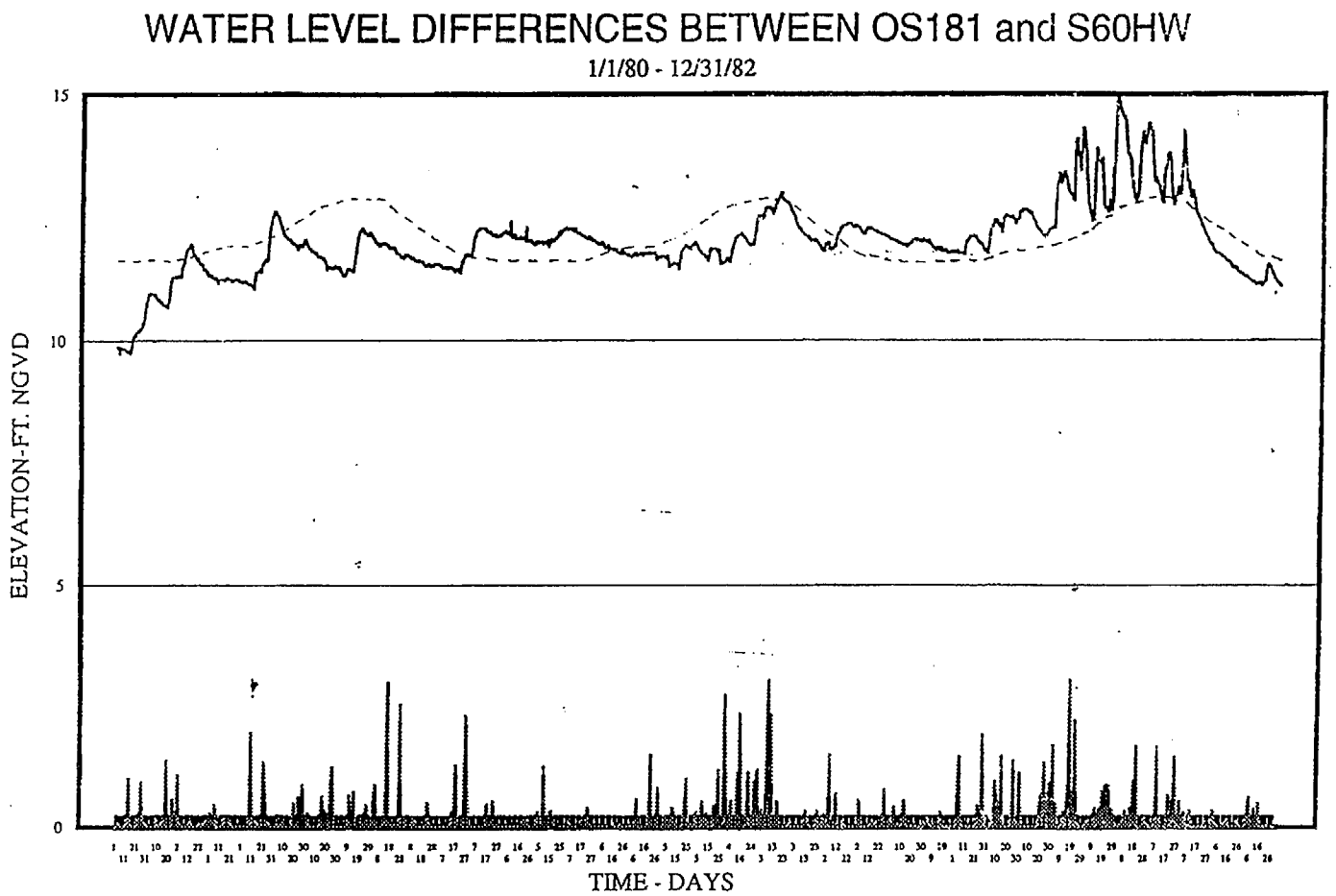

WATER LEVEL DIFFERENCES BETWEEN OS181 and S60HW
1/1/80 - 12/31/82
15
10
5
0
ELEVATION-FT. NGVD
TIME - DAYS
AVERAGE WATER LEVEL DIFFERENCES BETWEEN OS181 & S60H
1/08/1970 - 12/31/1994

Figure 7

WATER LEVEL COMPARISONS BETWEEN OS181, S60H, & LAKE JOEL WELL

10/1/80 - 9/30/85

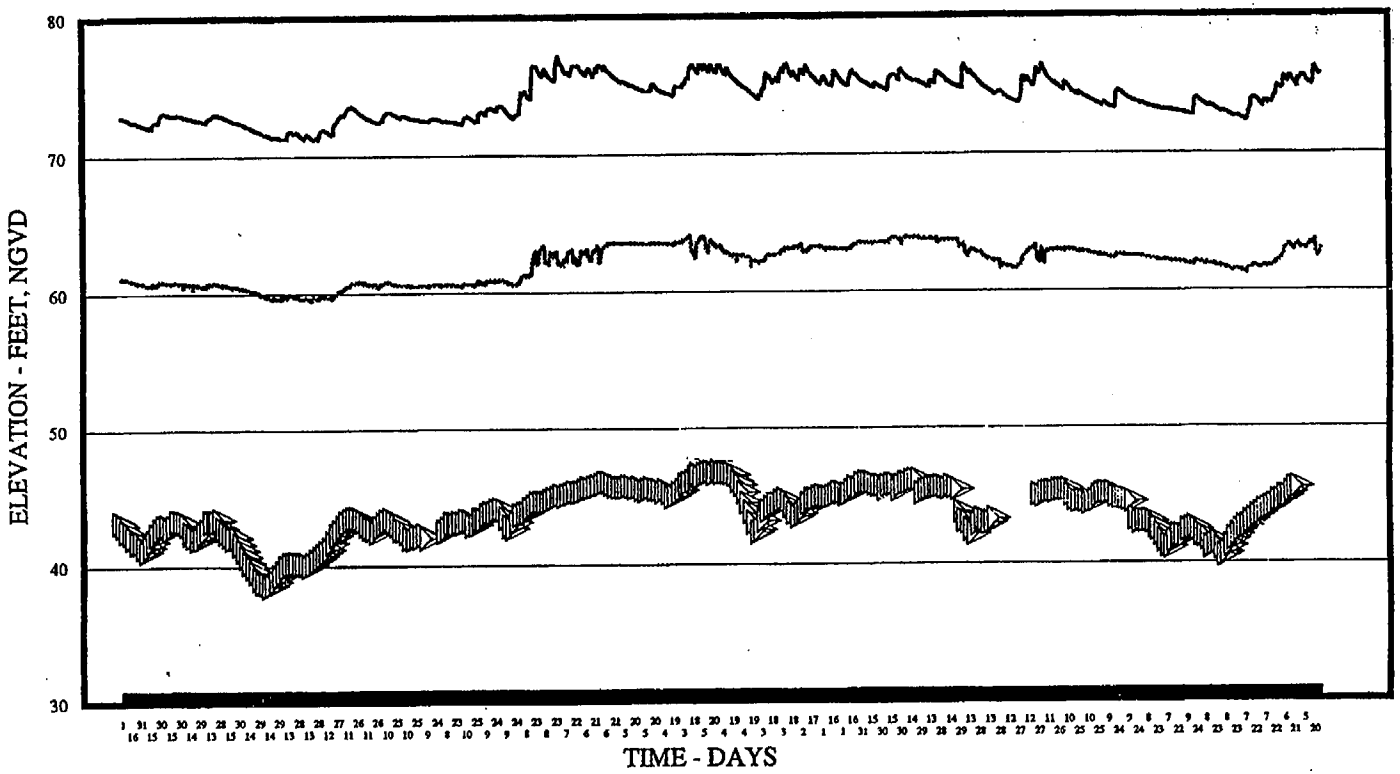


Figure 8

Appendix C. Monitoring Well Construction

Monitoring Well Construction

As a result of the Preliminary Analysis, it was determined that additional water table and rainfall data would help better define the ground water table response to local rainfall under different soil types, and the water table decline in relation to lake level drop. The SFWMD contracted a private company to install several monitoring wells in the Alligator Lake area. This appendix provides a summary of the well construction specifications.[1]

1. The well referred to as C-33 in this appendix is called Chestnut throughout the rest of the report.

PSI Environmental Geotechnical Construction
Consulting • Engineering • Testing

October 31, 1997
Project No. 771-75068

TO: South Florida Water Management District
3301 Gun Club Road
West Palm Beach, Florida 33406

Attention: Mr. David Butler

SUBJECT: Monitoring Well Installation
Alligator Chain of Lakes
Near St. Cloud, Florida

Dear Mr. Butler:

In accordance with our written agreement with the South Florida Water Management District, **Professional Service Industries, Inc. (PSI)** has completed the scope of work outlined in PSI's October 8, 1997 proposal. This letter presents the factual data obtained from the study.

Soil Borings

Eleven (11) Standard Penetration Test (SPT) borings were drilled, one at each of the monitoring well locations you requested. The SPT borings were drilled using procedures outlined in ASTM D 1586, and samples of the subsoils were obtained at frequent vertical intervals. The samples were classified by an engineer in accordance with the Unified Soil Classification System (ASTM D 2487). Logs of the borings are presented in the attached Sheets 1 and 2. Soils found in the borings generally consisted of clean sands, hardpan and then deeper clean sands.

Monitoring Wells

Two (2) inch diameter by 20 feet deep PVC monitoring wells were installed, one at each of eleven requested locations. The wells were set within an 8-inch diameter hollow stem auger, and screened within a depth interval of 10 to 20 feet below ground surface. Two-inch diameter solid PVC casing was used to extend the wells to above the ground surface. At eight of the locations, companion shallow (i.e., 10 feet deep) monitoring wells were installed, with the screened interval between 5 and 10 feet below existing ground level. For both typical wells, the screened interval was sand packed (6/20 silica sand), a bentonite plug was constructed above the screened interval, and the wells were filled with cement grout to ground surface. Details regarding monitoring well construction are included in Appendix A of this report.

Professional Service Industries, Inc. • 2540 Metrocentre Boulevard, Suite 1 • West Palm Beach, FL 33407 • Phone 561/689-3400 • Fax 561/684-9398

--o0o--

Thank you for the opportunity to provide these services. Should you have any questions, please call.

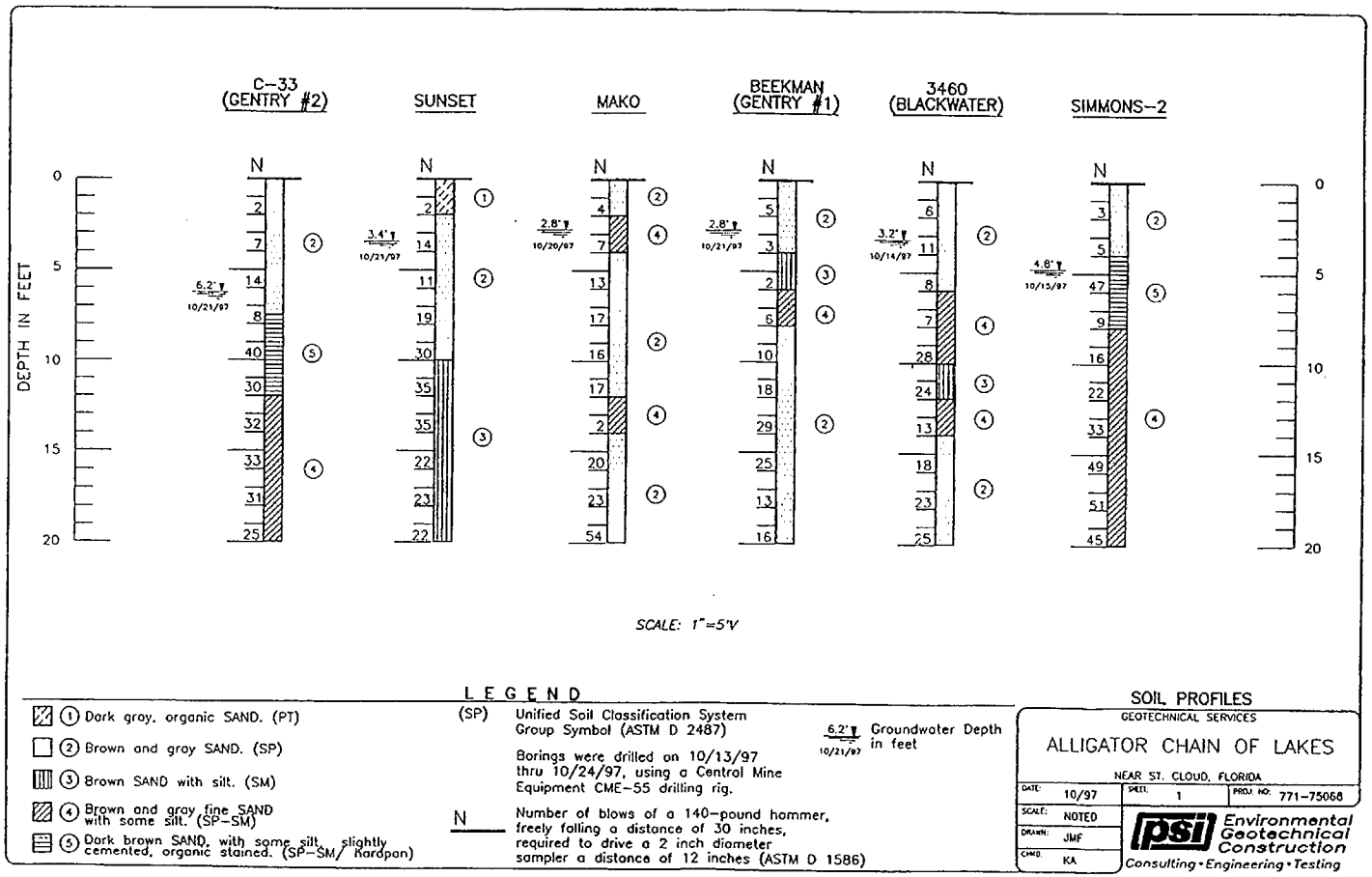
Very truly yours,

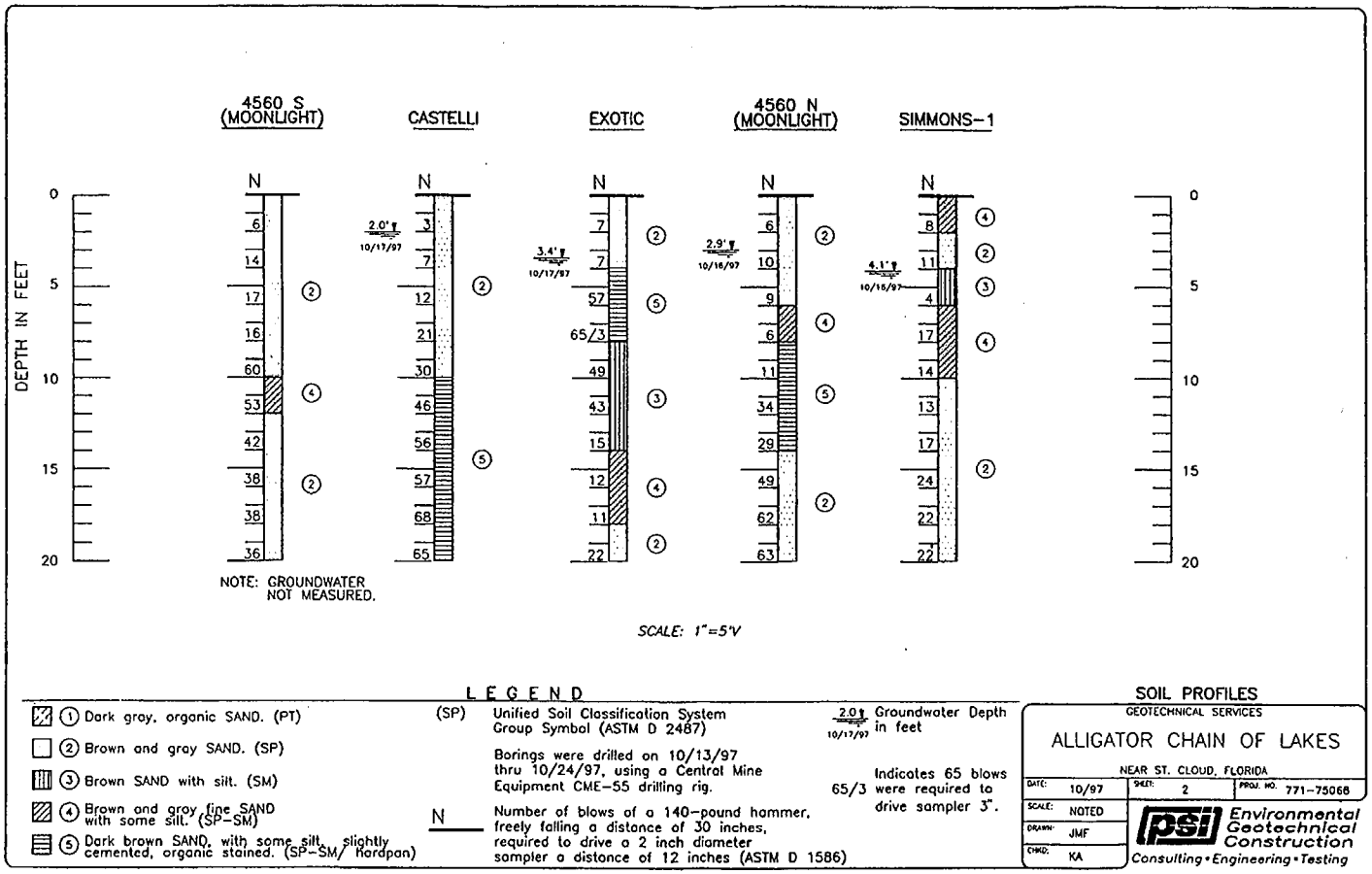
PROFESSIONAL SERVICE INDUSTRIES, INC.

Kevin E. Aubry, P.E.
Project Engineer
FL Registration No. 38175

KEA:dsw
75068.RPT

Attachments


C-33 (GENTRY #2)
SUNSET
MAKO
BEEKMAN (GENTRY #1)
3460 (BLACKWATER)
SIMMONS-2
DEPTH IN FEET
N
6.2' 10/21/97
3.4' 10/21/97
2.8' 10/20/97
2.8' 10/21/97
3.2' 10/14/97
4.8' 10/15/97
SCALE: 1"=5'V
LEGEND
① Dark gray, organic SAND. (PT)
② Brown and gray SAND. (SP)
③ Brown SAND with silt. (SM)
④ Brown and gray fine SAND with some silt. (SP-SM)
⑤ Dark brown SAND, with some silt, slightly cemented, organic stained. (SP-SM/ Hardpan)
(SP) Unified Soil Classification System Group Symbol (ASTM D 2487)
Borings were drilled on 10/13/97 thru 10/24/97, using a Central Mine Equipment CME-55 drilling rig.
N Number of blows of a 140-pound hammer, freely falling a distance of 30 inches, required to drive a 2 inch diameter sampler a distance of 12 inches (ASTM D 1586)
6.2' 10/21/97 Groundwater Depth in feet
SOIL PROFILES
GEOTECHNICAL SERVICES
ALLIGATOR CHAIN OF LAKES
NEAR ST. CLOUD, FLORIDA
DATE: 10/97
SHEET: 1
PROJ NO: 771-75068
SCALE: NOTED
DRAWN: JMF
CHKD: KA
psi Environmental Geotechnical Construction
Consulting • Engineering • Testing



LEGEND

- ① Dark gray, organic SAND. (PT)
- ② Brown and gray SAND. (SP)
- ③ Brown SAND with silt. (SM)
- ④ Brown and gray fine SAND with some silt. (SP-SM)
- ⑤ Dark brown SAND, with some silt, slightly cemented, organic stained. (SP-SM/ Hardpan)

(SP) Unified Soil Classification System Group Symbol (ASTM D 2487)

Borings were drilled on 10/13/97 thru 10/24/97, using a Central Mine Equipment CME-55 drilling rig.

N — Number of blows of a 140-pound hammer, freely falling a distance of 30 inches, required to drive a 2 inch diameter sampler a distance of 12 inches (ASTM D 1586)

2.0 ▼ 10/17/97 Groundwater Depth in feet

65/3 Indicates 65 blows were required to drive sampler 3".

SOIL PROFILES

GEOTECHNICAL SERVICES

ALLIGATOR CHAIN OF LAKES

NEAR ST. CLOUD, FLORIDA

DATE:	10/97	SHEET:	2	PROJ. NO.	771-75068
SCALE:	NOTED				
DRAWN:	JMF				
CHKD:	KA				

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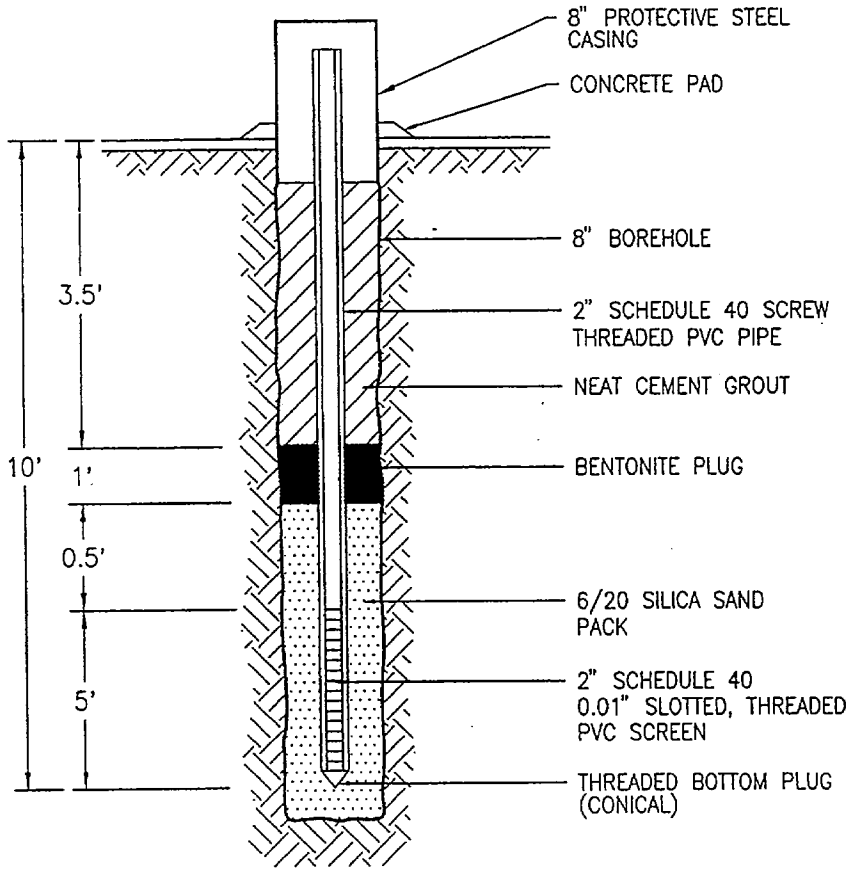
APPENDIX A

MONITORING WELL DETAILS

GROUNDWATER MONITOR WELL DETAIL

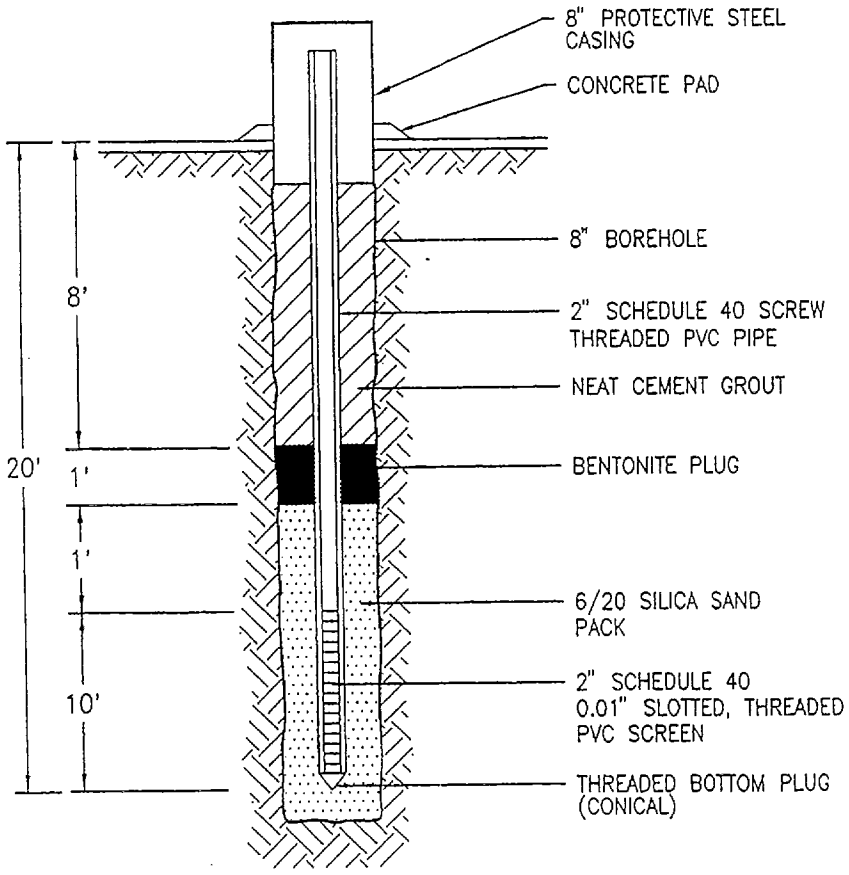


10 FOOT MONITOR WELL DETAIL
ALLIGATOR CHAIN OF LAKES, NEAR ST. CLOUD, FLORIDA

psi GEOTECHNICAL SERVICES
Consulting • Engineering • Testing

DRAWN BY:	JMF	SCALE:	NTS	PROJ. NO.:	771-75068
CHKD. BY:	KA	DATE:	OCT. 97	DWG.:	A1

GROUNDWATER MONITOR WELL DETAIL



20 FOOT MONITOR WELL DETAIL

ALLIGATOR CHAIN OF LAKES, NEAR ST. CLOUD, FLORIDA

psi GEOTECHNICAL SERVICES
Consulting • Engineering • Testing

DRAWN BY:	JMF	SCALE:	NTS	PROJ. NO.:	771-75068
CHKD. BY:	KA	DATE:	OCT. 97	DWG.:	A2

SCHEDULE OF MONITORING WELLS

LOCATION	SPT	WELLS	
		10'	20'
1 - C-33 (GENTRY #2)	20'	1	1
2 - SUNSET	20'		1
3 - MAKO	20'		1
4 - BEEKMAN (GENTRY #1)	20'	1	1
5 - 3460 (BLACKWATER)	20'	1	1
6 - SIMMONS-2	20'	1	1
7 - 4560 S (MOONLIGHT)	20'	1	1
8 - CASTELLI	20'	1	1
9 - EXOTIC	20'		1
10 - 4560 N (MOONLIGHT)	20'	1	1
11 - SIMMONS-1	20'	1	1
	220'	8	11

SHEET A-3
Project No. 771-75068

Appendix D. Technical Specifications of Monitoring Equipment

Technical Specifications of Monitoring Equipment

OV7. SPECIFICATIONS

Electrical specifications are valid over a -25° to +50°C range unless otherwise specified.

PROGRAM EXECUTION RATE

System tasks initiated in sync with real-time up to 64 Hz. One measurement with data transfer is possible at this rate without interruption. Measurement rates up to 750 Hz are possible over short intervals using Burst measurement.

ANALOG INPUTS

NUMBER OF CHANNELS: 6 differential or up to 12 single-ended. Each differential channel can be configured as two single-ended channels

CHANNEL EXPANSION: The AM416 Relay Multiplexer allows up to 64 single-ended channels to multiplex into four CR10X single-ended channels. The AM25T allows 25 thermocouples to multiplex into one differential channel. Several multiplexers can be connected to one CR10X.

RANGE AND RESOLUTION: Ranges are software selectable for any channel. The resolution for differential measurements is better than that for single-ended measurements because two measurements are averaged together.

Full Scale Input Range (mV)	*Resolution (µV) Differential*	*Single-Ended*
±2500	333	666
±250	33.3	66.6
±25	3.33	6.66
±7.5	1.00	2.00
±2.5	0.33	0.66

ACCURACY OF VOLTAGE MEASUREMENTS AND ANALOG OUTPUT VOLTAGES: ±0.1% of FSR, ± 0.05% of FSR, (0 to 40°C)(e.g., ±0.1% FSR = ±5.0 mV for ±2500 mV range)

INPUT SAMPLE RATES: The fast and slow A/D conversions use signal integration times of 0.25 and 2.72 ms, respectively. Two integrations occurring 1/2 of an AC cycle apart, are used with the 60 Hz or 50 Hz noise rejection option. Differential measurements incorporate two integrations with reversed input polarities to reduce thermal offset and common mode errors. Input sample rates include the time required to measure and convert to engineering units.

Fast single-ended voltage	2.6 ms
Fast differential voltage:	4.2 ms
Slow single-ended voltage:	5.1 ms
Slow differential voltage:	9.2 ms
Differential with 60 Hz rejection:	25.9 ms
Fast differential thermocouple:	8.6 ms

INPUT NOISE VOLTAGE (for ±2.5 mV range)
Fast differential: 0.62 µV RMS
Slow differential: 0.25 µV RMS
Differential with 60 Hz rejection: 0.18 µV RMS

COMMON MODE RANGE: ±2.5 V

DC COMMON MODE REJECTION: > 140 dB

NORMAL MODE REJECTION: 70 dB (60 Hz with slow differential measurement).

INPUT CURRENT: ±9 nA maximum

INPUT RESISTANCE: 20 Gohms typical

EXCITATION OUTPUTS

DESCRIPTION: 3 switched excitations, active during measurement, with one output active at a time. Non-active outputs are high impedance.

RANGE: ±2.5 V

RESOLUTION: 0.67 mV

ACCURACY: ±2.5 mV (0° to 40°C), ±5 mV (-25° to +50°C)

OUTPUT CURRENT: ±25 mA

FREQUENCY SWEEP FUNCTION: A swept frequency, square wave output between 0 and 2.5 V is provided for vibrating wire transducers. Timing and frequency range are specified by the instruction.

RESISTANCE AND CONDUCTIVITY MEASUREMENTS

MEASUREMENT TYPES: Using the 3 switched excitation channels, the CR10X can measure resistance and conductivity by means of ratiometric bridge measurements. Standard bridge measurements include 8-wire and 4-wire full bridge, 4-wire, 3-wire, and 2-wire half bridge. Where appropriate, dual polarity bridge measurements are used to eliminate DC errors. AC resistance measurements use a dual polarity 0.75 ms excitation pulse for ionic depolarization; signal integration occurs over the last 0.25 ms.

ACCURACY: ±0.02% of full scale input range used, limited by the matching bridge resistors (e.g., ±0.02% of ±250 mV full-scale input range = ± 100 µV). The excitation voltage should be programmed so the bridge output matches the full scale input voltage range.

PERIOD AVERAGING MEASUREMENTS

DEFINITION: The time period for a specified number of cycles of an input signal is measured, then divided by the number of cycles to obtain the average period of a single cycle. Improved timing resolution and noise reduction can be obtained by averaging over many cycles.

INPUTS: Any of the 12 single-ended analog input channels can be selected for period averaging. Signal amplitude reduction or AC coupling is normally required.

INPUT FREQUENCY RANGE:

Range Code	*Min volts (peak-peak) @ Max. Freq.**	*Max. Input Frequency*
1	2 mV	8 kHz
2	5 mV	20 kHz
3	12 mV	40 kHz
4	2000 mV	150 kHz

*AC voltage must be centered around CR10X ground.

RESOLUTION: 35 ns divided by the number of cycles measured

ACCURACY: ± (0.01% of reading + RESOLUTION)

TIME REQUIRED FOR MEASUREMENT: Signal period times the number of cycles measured plus 1.5 cycles.

PULSE COUNTERS

NUMBER OF PULSE COUNTER CHANNELS: 2 eight-bit or 1 sixteen-bit, software selectable

MAXIMUM COUNT RATE: 16 kHz, eight-bit counter; 250 kHz, sixteen-bit counter. Channels are scanned at 8 or 64 Hz (software selectable).

MODES: Switch closure, high frequency pulse, and low level AC.

SWITCH CLOSURE MODE
Minimum Switch Closed Time: 5 ms
Minimum Switch Open Time: 6 ms
Maximum Bounce Time: 1 ms open without being counted

HIGH FREQUENCY PULSE MODE
Minimum Pulse Width: 1 µs
Maximum Input Frequency: 500 kHz
Voltage Thresholds: Count upon transition from below 1.5 V to above 3.5 V
Maximum Input Voltage: ±20 V.

LOW LEVEL AC MODE
(Typical of magnetic pulse flow transducers or other low voltage, sine wave outputs).
Input Hysteresis: 8 mV
Maximum AC Input Voltage: 20 V RMS.

*Minimum AC Input Voltage (sine wave mV RMS)**	*Range (Hz)*
20	1 to 1000
200	0.5 to 10,000
1000	0.3 to 20,000

*16-bit config. or 64 Hz scan req'd for freq. > 2048 Hz.

DIGITAL I/O PORTS

8 ports, software selectable as binary inputs or control outputs. 3 ports can be configured to count switch closures up to 40 Hz

OUTPUT VOLTAGES (no load): high 5.0 V ±0.1 V, low < 0.1 V

OUTPUT RESISTANCE: 500 ohms

INPUT STATE: high 3.0 V to 5.5 V; low -0.5 V to 0.8 V

INPUT RESISTANCE: 100 kohms

SDI-12 INTERFACE STANDARD

This communication protocol, developed for microprocessor-based hydrologic and environmental sensors, is available in the CR10X

SENSOR CONNECTIONS: Any digital I/O Port (for asynchronous communication), 12 V power, and ground. Up to ten SDI-12 sensors can be connected to each port.

CR10TCR THERMOCOUPLE REFERENCE

POLYNOMIAL LINEARIZATION ERROR: Typically <±0.5°C over -35 to +50°C range and <±0.1°C over -24 to +45°C range

INTERCHANGEABILITY ERROR: Typically <±0.2°C over 0 to +60°C range increasing to ±0.4°C at -35°C.

EMI and ESD PROTECTION

Emissions: Meets or exceeds the following standards:
Radiated: per EN 55022:1987 Class B
Conducted: per EN 55022:1987 Class B

Immunity: Meets or exceeds the following standards:
ESD: per IEC 801-2:1984 8kV air discharge
RF: per IEC 801-3:1984 3V/m, 27 500 MHz
EFT: per IEC 801-4:1988 1kV mains, 500 V other

CPU AND INTERFACE

PROCESSOR: Hitachi 6303

MEMORY: 128 K Flash and 128 K SRAM standard. Additional 1 or 2M Flash available as options

DISPLAY: 8 digit LCD (0.5" digits)

PERIPHERAL INTERFACE: 9 pin D-type connector for keyboard display, storage module, modem, printer, card storage module, and RS-232 adapter. Baud rates selectable at 300, 1200, 9600 and 76,800. ASCII communication protocol is one start bit, one stop bit, eight data bits (no parity).

CLOCK ACCURACY: ±1 minute per month

SYSTEM POWER REQUIREMENTS

VOLTAGE: 9.6 to 16 V

TYPICAL CURRENT DRAIN: 1 mA quiescent, 13 mA during processing and 46 mA during analog measurement

BATTERIES: Any 12 V battery can be connected as a primary power source. Several power supply options are available from Campbell Scientific. The Model CR2430 lithium battery for clock and RAM backup has a capacity of 270 mAhr.

PHYSICAL SPECIFICATIONS

SIZE: 7.6" x 3.5" x 1.5" - Measurement & Control Module; 9" x 3.5" x 2.9" with CR10WP Wiring Panel. Additional room required for connectors

WEIGHT: 2 lbs

WARRANTY

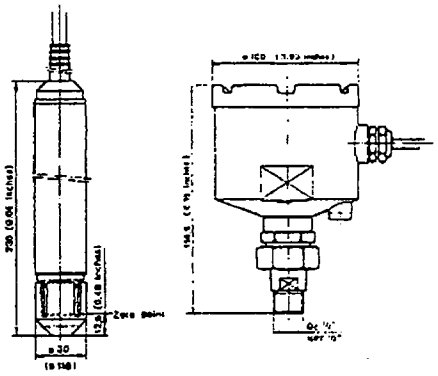
Three years against defects in materials and workmanship.

rittmeyer

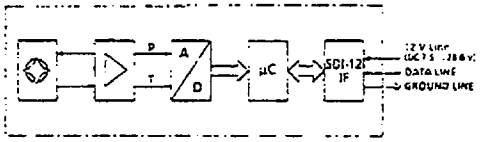
Mechanical Construction

Submersible type
MPSDIT.xxx

Screw-in
MPSDIG.xxx



Block Diagram



Control and Programming

Via data logger or a personal computer (in connection with a SDI-12 to RS232 converter) the following communications and adjustments are possible:

- Recalibration
- Free adjustement of offset and measuring-span (scaling)
- Choice of output-parameters like measurement units etc.

Technical Characteristics

Measuring ranges:	MPSDIT.xxx 0 ... 0.5 / 1 / 2 / 5 / 10 / 20 bar 0 ... 7.5 / 15 / 30 / 75 / 150 / 300 psig MPSDIG.xxx 0 ... 0.5 / 1 / 2 / 5 / 10 / 20 / 50 bar 0 ... 7.5 / 15 / 30 / 75 / 150 / 300 / 750 psig
Overpressure:	3 to 6 times (depending on the range)
Accuracy of pressure/level:	0.05 % of full scale or 3 mm (0.01 ft) for ranges ≤ 5 m (15 ft)
Accuracy of temp.:	≤ 1 °C
Operating temp. range:	-20 °C ...+ 70 °C (-4 °F ... + 158 °F)
Min./Max. temperature:	-40 °C ...+ 85 °C (-40 °F ... + 185 °F)
Power supply:	DC 7.5 .. 28.8 V
Power consumption:	less than 30 mAh a day (4 measurements per hour)
Temperature influence:	typ. ≤ 30 ppm/°C of full scale in the range -20 °C ... +70 °C max. ≤ 50 ppm/°C of full scale in the range -20 °C ... +70 °C
Cable length (Bus):	maximum length allowed: 600 m (1800 ft)
Communication:	Bidirectional serial bus, multidrop communication, up to 10 sensors, SDI-12 protocol, 1200 baud, 7 bit, even parity
Overvoltage protection:	Built-in protector up to 2000 V (transient)

Rittmeyer

A company of Kabelwerke Brugg Holding Ltd, Switzerland

Represented by:

9503 Va, AH | Subject to change | 21.040.0002200.001.002.01.4.4

Rittmeyer AG
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Rittmeyer Italiana s r.l
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Rittmeyer S.A.
Calle Julián Camarillo 26-3º
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E-28037 Madrid
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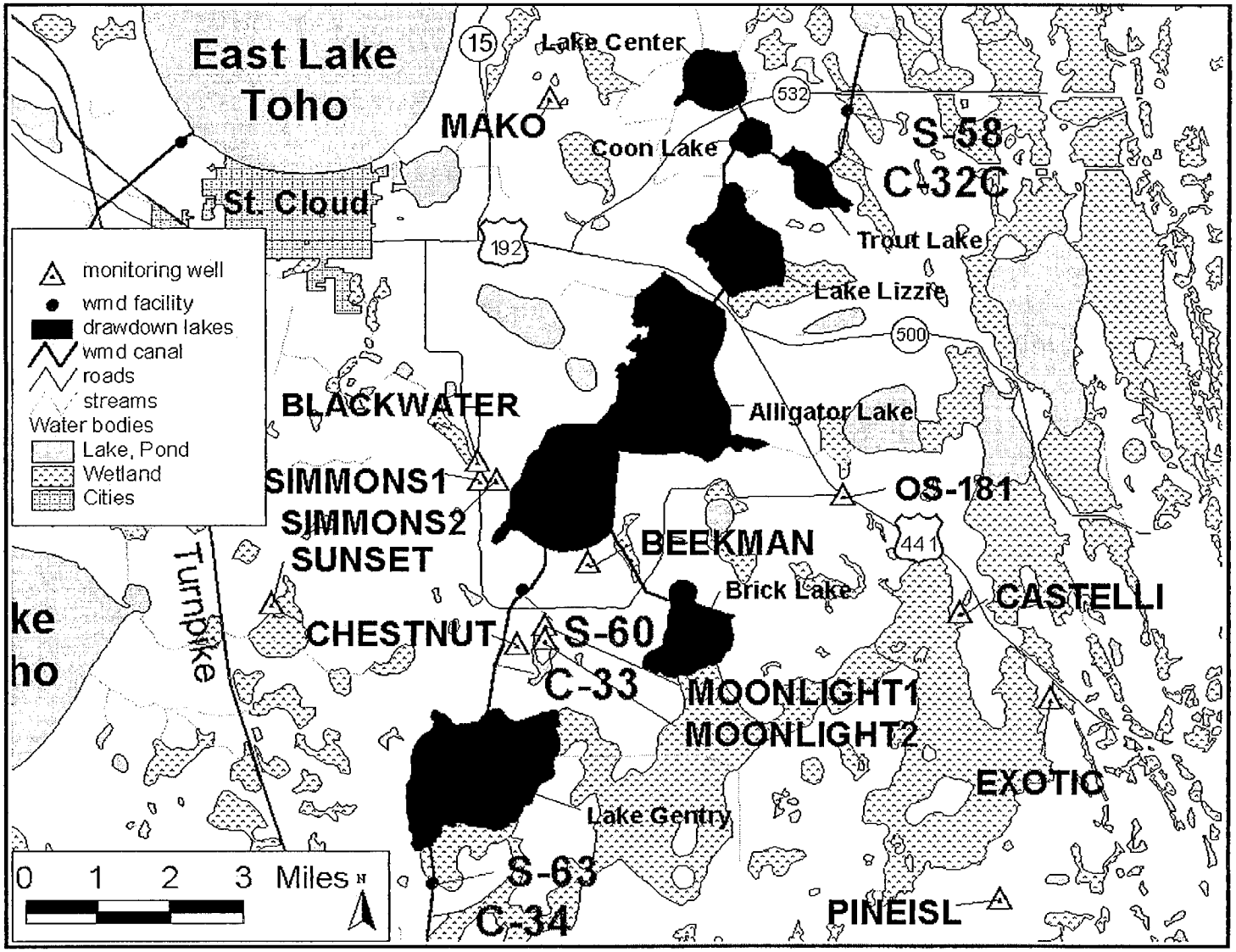
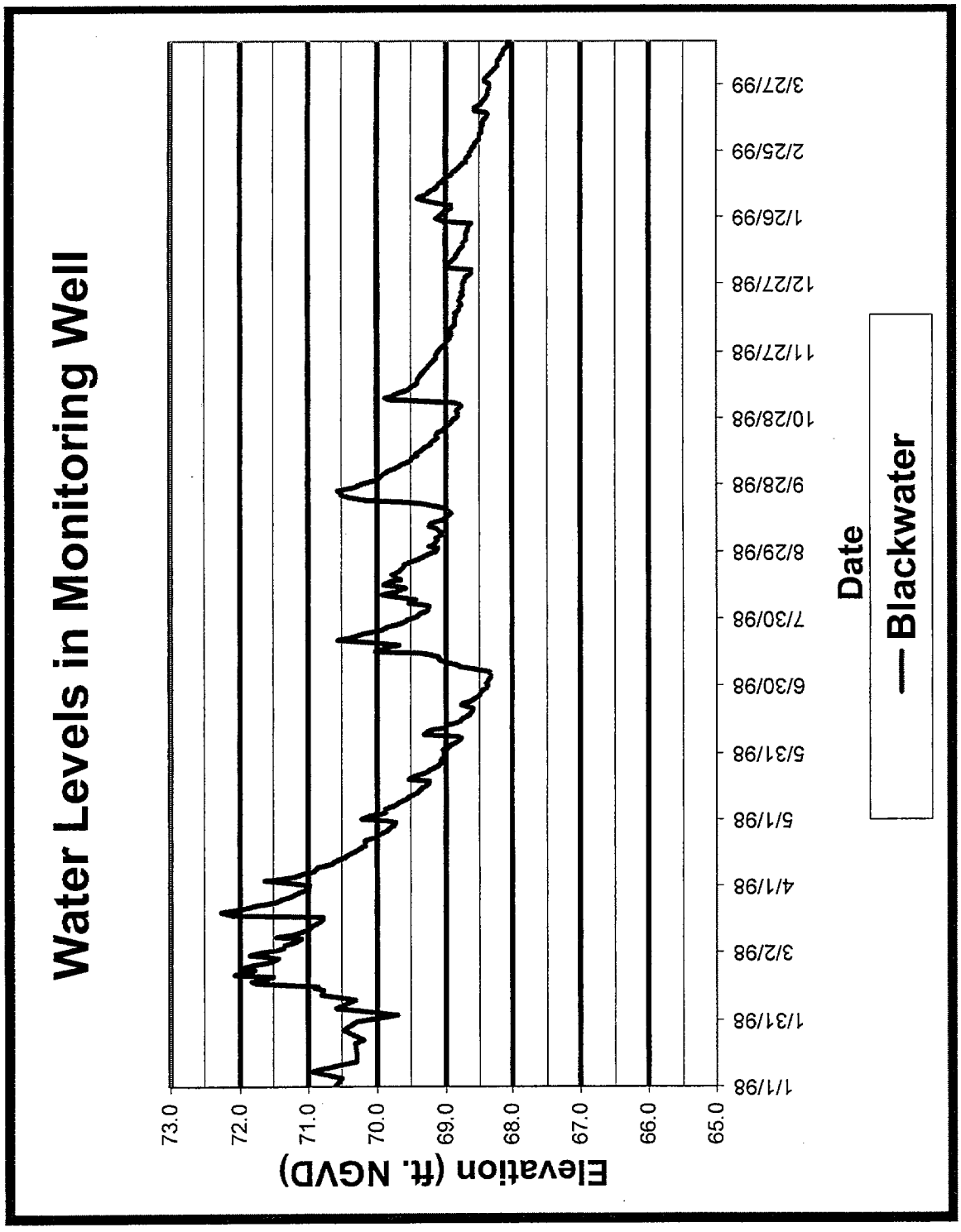
Telefax (91) 304 31 49

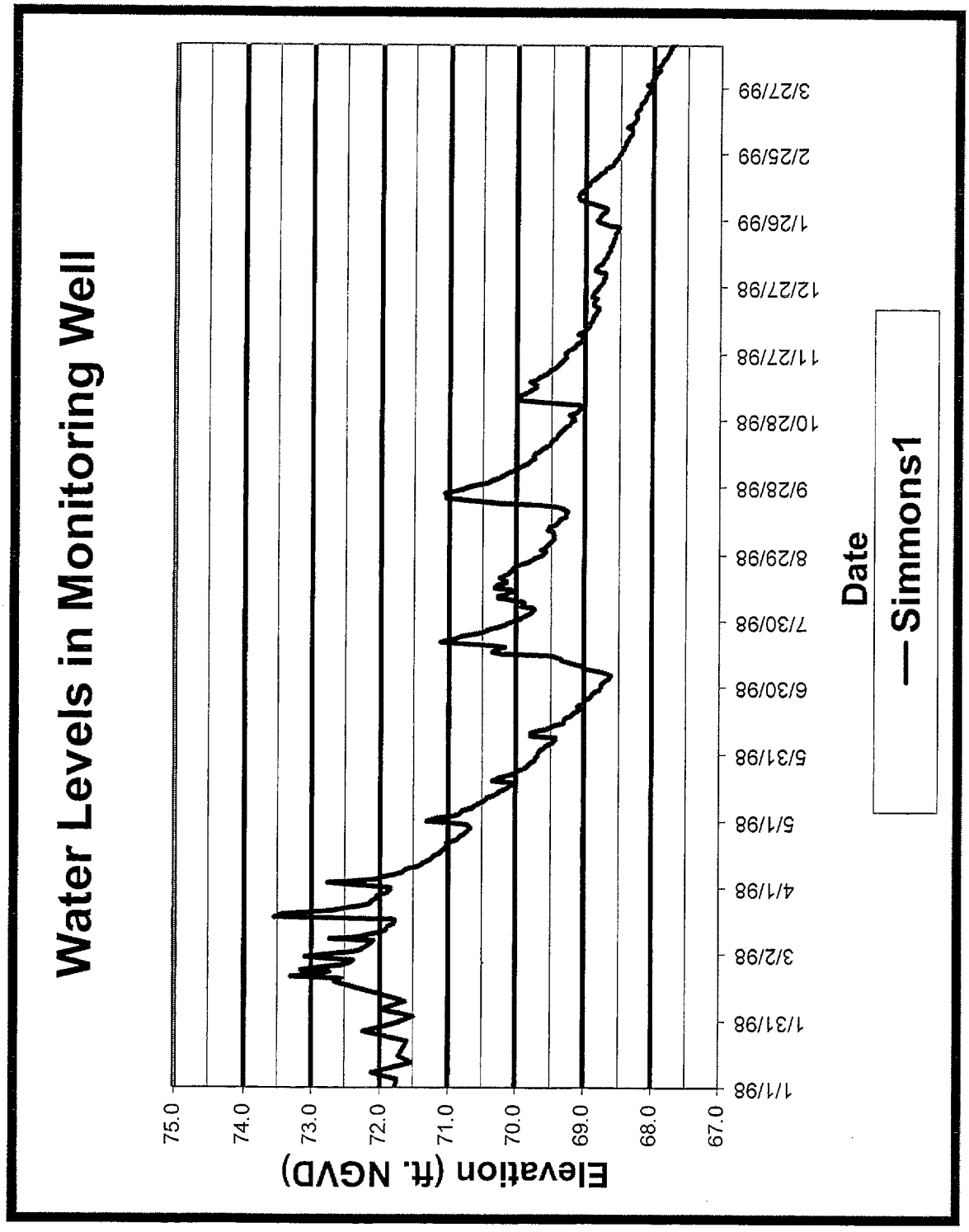
Appendix E. Data from Monitoring Wells

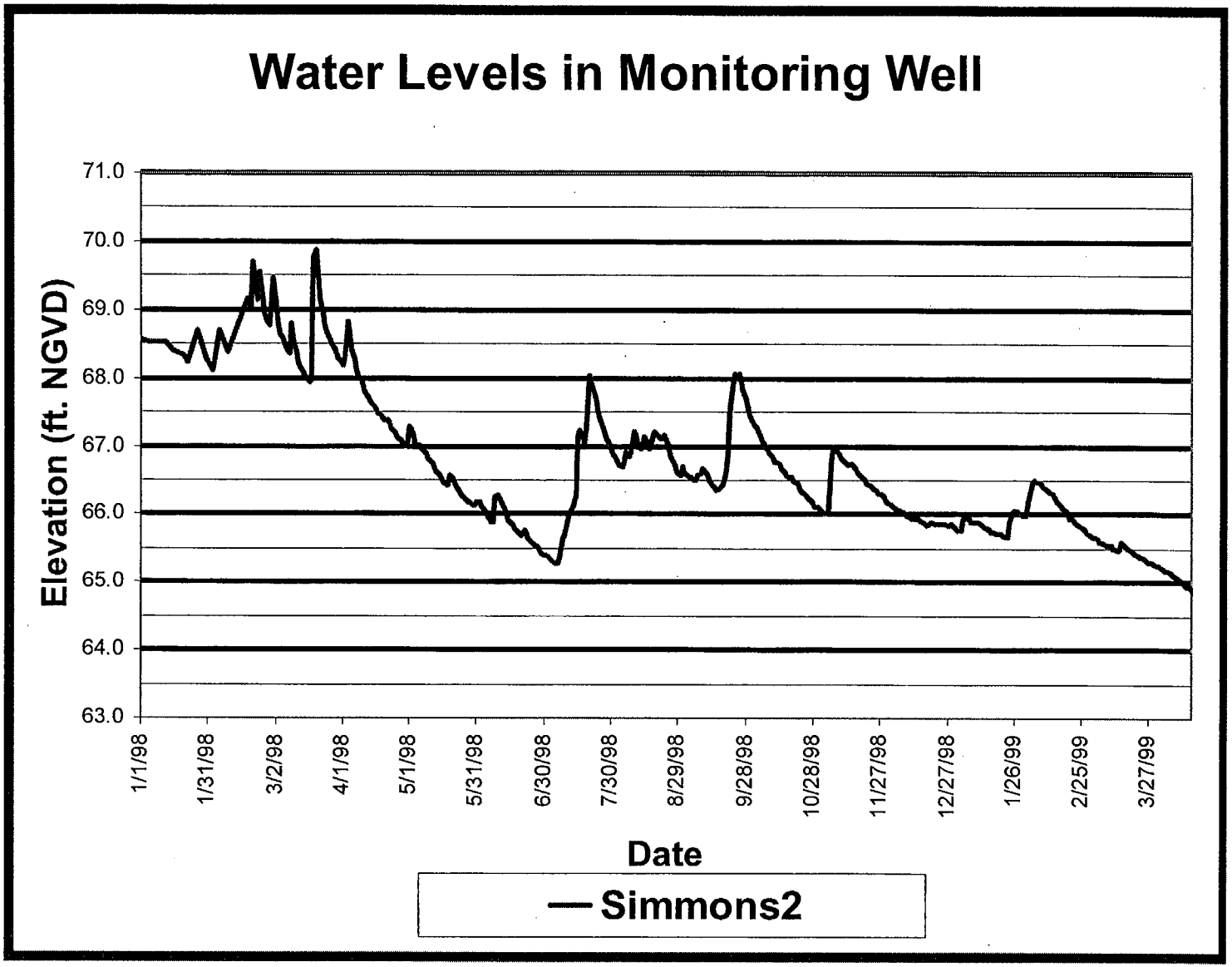
Data from Monitoring Wells

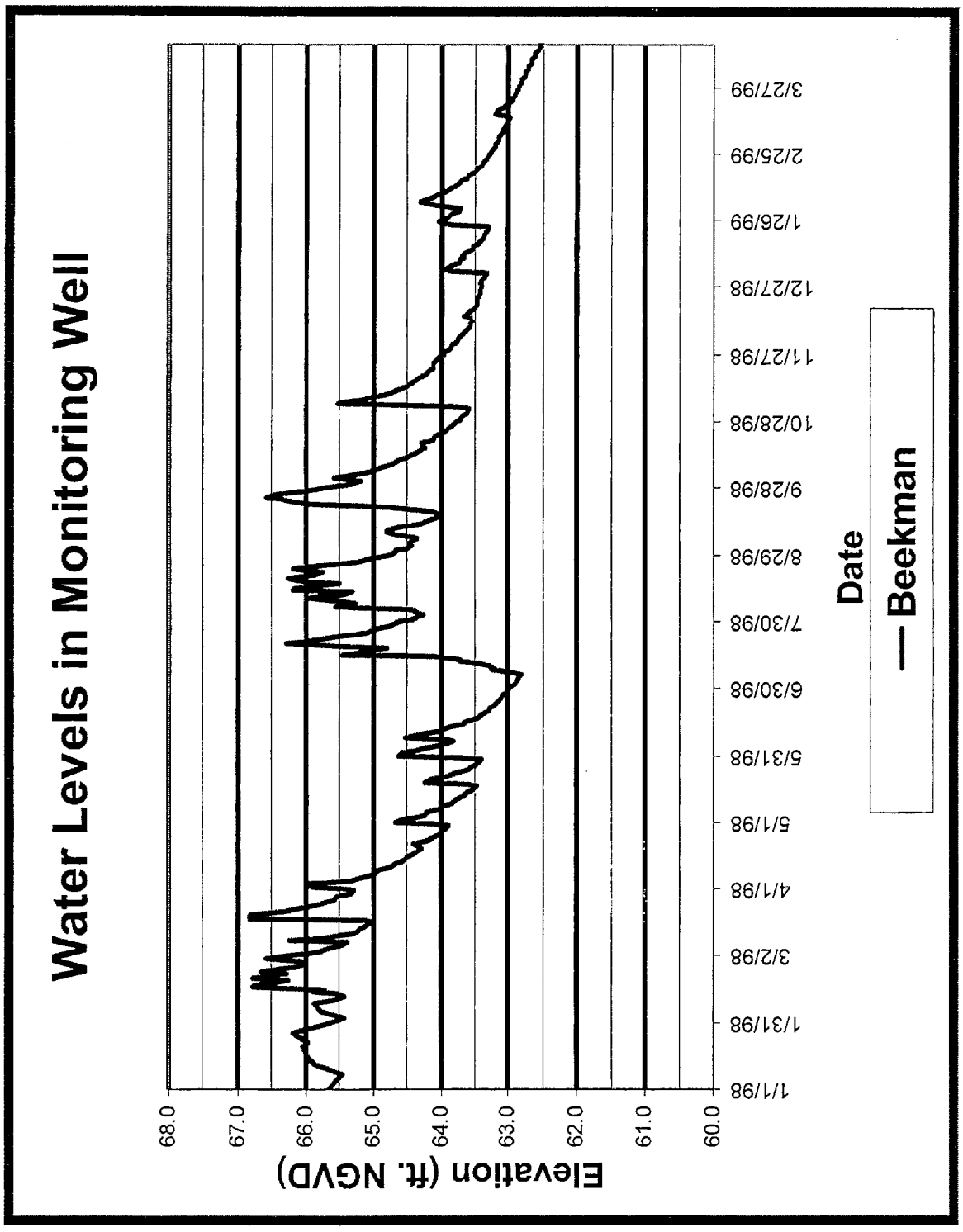
The following graphs show water levels in surficial aquifer monitoring wells in the Alligator Lake area from January 1998 through mid-April 1999.


East Lake
Toho
St. Cloud
15
Lake Center
MAKO
532
Coon Lake
S-58
C-32C
192
Trout Lake
Lake Lizzie
500
BLACKWATER
Alligator Lake
SIMMONS1
SIMMONS2
SUNSET
OS-181
BEEKMAN
441
Brick Lake
CASTELLI
Turnpike
CHESTNUT
S-60
C-33
MOONLIGHT1
MOONLIGHT2
EXOTIC
Lake Gentry
S-63
C-34
PINEISL
monitoring well
wmd facility
drawdown lakes
wmd canal
roads
streams
Water bodies
Lake, Pond
Wetland
Cities
0 1 2 3 Miles
N


Water Levels in Monitoring Well
Elevation (ft. NGVD)
73.0
72.0
71.0
70.0
69.0
68.0
67.0
66.0
65.0
1/1/98
1/31/98
3/2/98
4/1/98
5/1/98
5/31/98
6/30/98
7/30/98
8/29/98
9/28/98
10/28/98
11/27/98
12/27/98
1/26/99
2/25/99
3/27/99
Date
Blackwater


Water Levels in Monitoring Well
Elevation (ft. NGVD)
75.0
74.0
73.0
72.0
71.0
70.0
69.0
68.0
67.0
1/1/98
1/31/98
3/2/98
4/1/98
5/1/98
5/31/98
6/30/98
7/30/98
8/29/98
9/28/98
10/28/98
11/27/98
12/27/98
1/26/99
2/25/99
3/27/99
Date
Simmons1


Water Levels in Monitoring Well
Elevation (ft. NGVD)
71.0
70.0
69.0
68.0
67.0
66.0
65.0
64.0
63.0
1/1/98
1/31/98
3/2/98
4/1/98
5/1/98
5/31/98
6/30/98
7/30/98
8/29/98
9/28/98
10/28/98
11/27/98
12/27/98
1/26/99
2/25/99
3/27/99
Date
Simmons2


Water Levels in Monitoring Well
Elevation (ft. NGVD)
68.0
67.0
66.0
65.0
64.0
63.0
62.0
61.0
60.0
1/1/98
1/31/98
3/2/98
4/1/98
5/1/98
5/31/98
6/30/98
7/30/98
8/29/98
9/28/98
10/28/98
11/27/98
12/27/98
1/26/99
2/25/99
3/27/99
Date
Beekman